Comparative Cost Analysis and Dynamic Analysis of RCC, Steel and Steel-Concrete Composite Frame of Low, Medium & High Rise Buildings

Submitted in partial fulfilment of the requirements

of the degree of

MASTER OF TECHNOLOGY

in

CIVIL ENGINEERING

by

Balvinder Singh

(11506392)

Supervisor

Mr. Paramveer Singh

LOVELY PROFESSIONAL UNIVERSITY

Transforming Education Transforming India

School of Civil Engineering

LOVELY PROFESSIONAL UNIVERSITY, PHAGWARA

2017

DECLARATION

I, Balvinder Singh (Regd. No. 11506392), hereby declare that this thesis report entitled **"Comparative cost analysis and dynamic analysis of RCC, steel and steel-concrete composite frame of low, medium & high rise buildings"** submitted in the partial fulfilment of the requirements for the award of degree of Master of Civil Engineering, in the School of Civil Engineering, Lovely Professional University, Phagwara, is my own work. This matter embodied in this report has not been submitted in part or full to any other university or institute for the award of any degree.

Date: **Balvinder Singh**

Place:

CERTIFICATE

Certified that this project report entitled **"Comparative cost analysis and dynamic analysis of RCC, steel and steel-concrete composite frame of low, medium & high rise buildings"** submitted individually by student of School of Civil Engineering, Lovely Professional University, Phagwara, carried out the work under my supervision for the Award of Degree. This report has not been submitted to any other university or institution for the award of any degree.

Signature of Supervisor

Paramveer Singh

Assistant Professor

ACKNOWLEDGEMENT

I would like to express my sincere thanks to **Dr. V. Rajesh Kumar - Dean,** School Of Civil Engineering, Lovely Professional University, Punjab for extending all necessary help during my thesis work.

I would like to express my heartfelt gratitude and deep sense of thankfulness to **Mr R Manoharan - Head of the Department**, School Of Civil Engineering, Lovely ProfessionalUniversity, Punjab for providing her valuable suggestions during my thesis work.

I wish to express my sincere thanks to **Mr. Paramveer Singh-Assistant Professor,** Internal Guide, School of Civil Engineering, Lovely Professional University, Punjab for giving me a chance to do my thesis work under his Guidance and support.

Signature of Student

Balvinder Singh

ABSTRACT

RCC is mostly used construction material in case of low rise and medium rise buildings in India. composite construction is considered as best choice when we deal with high rise buildings because of ductility features which are very useful in resisting earthquake. currently, steel-concrete composite construction is very popular because it fastens the construction speed, economical and utilizes both the properties of steel & concrete. Concrete structures are heavy & possess more self-weight (dead load), reduced stiffness and constraint of span length. So, the primary objective of present study is to compare the structural behavior of low, medium & high rise buildings situated in seismic zone-IV, with the RCC, steel & composite construction. Frame structure is either made of RCC, steel or steel-concrete composite sections. Their behavior will be analyzed by using the ETABS software & cost analysis of Beams & Columns is done in all three cases using MS- Excel software. Then all the results will be compared in order to find the economical building and better structural performance under equivalent static load analysis and response spectrum analysis. The main conclusion came out is that the composite construction is best in case of high rise buildings. As the comparison of steel , RCC & Composite frame buildings is done for 11, 21 and 31 story buildings, which conclude that composite frame Reponses better when subjected to earthquake loads in comparison with RCC & steel. Response Spectrum analysis give better results than Static analysis.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

mm	Millimeter
cm	Centimeter
m	Meter
sec	Second
m^2/kg	Meter square per kilogram
Kg/m^3	Kilogram per meter cube
MPa	Mega Pascal
^oC	Degree Celsius
c/c	Centre to Centre
Φ	Diameter
N	Newton
KN	Kilo Newton
KNm	Kilo Newton meter
Rs.	Indian Rupees

CHAPTER 1
INTRODUCTION

Low rise buildings, which is the category of building structure under which most of the building structures in India falls. Therefore structure members of reinforced concrete members are extensively employed in construction to make it convenient for the reasons like economical suitability which is one of the most important factors to be considered. But the need of development of taller buildings is an important point that needs be considered because of the exponential growth in the population of the cities now-a-days and also because of shortage of appropriate land to construct buildings in these cities. As a result of which a taller buildings (medium to high rise) are growing in numbers to fulfill needs of the cities where population is growing at an enormous scale. It has been observed that it is more effectual and economically convenient to use composite members in construction as compared to concrete members.

Due to which, the construction of medium and high rise building using composite members is becoming more popular in these days, which is solely on the basis of above mentioned advantages of buildings of these types over reinforced constructions which can now be termed as ‘Conventional method of construction’. Because the conventional type of construction methods *(*RCC) are either risky or cannot be adopted in Medium and High Rise Buildings because of increased amount of dead load with restriction in the span, framework and stiffness which may lead to quite dangers.

And reinforced concrete construction can be used for Low Rise Building because of opposite reasons listed above like less span restriction, normal or lesser loading (lesser as compared to Medium & High Rise Buildings).

In India, Use of composite construction is much less in comparison with other developing countries like Colombia, Brazil, Malaysia, China etc. So wherever economical new and improved construction methods like use of steel in construction needs to be well explored in order to overcome this issue which is also in line with development of the nation. But approach of using steel in construction of medium and high rise building is always economical solving problems faced in tall structures.

1.1 RCC Structures

Term RCC refers to “Reinforced cement concrete”. Concrete behaves better in compression than in tension. So to increase the tensile resistance capacity of structure, steel reinforcing bars are used in collaboration with concrete. This is most common concept of building construction and is used widely by engineers due to good bonding properties between steel & concrete. For the buildings with lower height, RCC is considered as best material for construction. All the design recommendations for RCC structures are taken as per IS:456 Codebook in India.

1.2 Steel Structures

When the Fabricated steel or Structural steel is used as a construction material for buildings, the term comes into picture is known as "steel structures". According to indian standards, different type of steel shaped members are used in steel buildings like I-section, angle section, channel sections etc. Being a lighter material, it is very useful in earthquake prone areas . the members are created into different shapes and sizes in the factories according to requirements at site. It also results in Faster construction. Steel structures are mainly used in constructing Industrial roofs and sheds. But in buildings ,there are different types of disadvantages of using the structural steel alone as a building material for beams & columns.

1.3 Composite Structures

A member is said composite, when a concrete member and steel component like Steel plate, I-section etc. are used together in such a way that they experience transfer of forces and moments in them, in order to take full advantages of steel in tension and concrete in compression are utilized together to get best capabilities of both of these. This additionally is economical. Structural engineers were forced to take a close look at the problem and come up with some better alternative (like hybrid use of materials based on one's particular and appropriate interest and engineering judgment) method of construction of these types of high rise buildings to increase overall performance by doing optimal changes in construction technology because of failure of many conventional low rise and multistory RCC structures. Because previously only two construction methods were there and needless to say the choice was generally made only among those two methods i.e. Concrete structure or masonry structure. Composite structures are used widely in taller buildings .

1.3.1 Composite beam:

When a slab made of concrete is placed over a steel member or an I-section to act as a single unit, is said to be a Composite Steel concrete beam as shown in Relative slippage is induced between both of these elements due to which these elements tend to behave as independent under the external loading. To make these elements to behave like a monolithic beam, there should not be any relative slip between the considered elements (concrete slab & I-section steel beam). Composite beam is behaves like a monolithic beam. Like in RCC structures the advantageous attributes of good performance of steel in tension and concrete in compression are combined by making appropriate connections between a pre-casted concrete slab and I-section beam of steel. Deflection values are comparatively lesser in case of steel beam because of its larger stiffness. In addition to that a steel beam section offers considerably more corrosion resistance and fire protection. In the present study, no composite beams are used. Only steel beams are used in composite structure as a design option because extensive research is done on Composite Beams previously.

1.3.2 composite columns :

There are mainly two types of columns are used in composite structures:

(1). CFST (Concrete Filled Steel Tubes).

(2) Fully Encased & Partially Encased Columns.

In composite column member, a steel (hot rolled steel) tubular section is filled with concrete. And both the steel and concrete shares same frictional bond (which makes them glued together) in an composite column thus they resist the application of external forces and also bears initial loads at the earlier time of construction thus also generally acting as supports which may reduce setup (supports and shuttering) which is required initially at the time of construction before filling them with concrete.

Concrete is later filled in the tubular steel columns. The collaboration of both steel and concrete is used as such so that to attain their capabilities in construction in a most effective manner. Size of foundations can be considerably reduced by using smaller and light foundations due to higher strength of steel.

Sometimes the casting of concrete around the steel is done at later stages which also aids in reducing the lateral deformations in the form of deflection and buckling of the column. It is also very efficient and convenient way to cast concrete in columns at later stages in case of high rise buildings thus reducing the time taken for construction and aiding in the speedy construction.

In this research work, Concrete filled steel tube columns of rectangular sections are used . The both types of columns are shown as below in Figure 1.1. & 1.2.

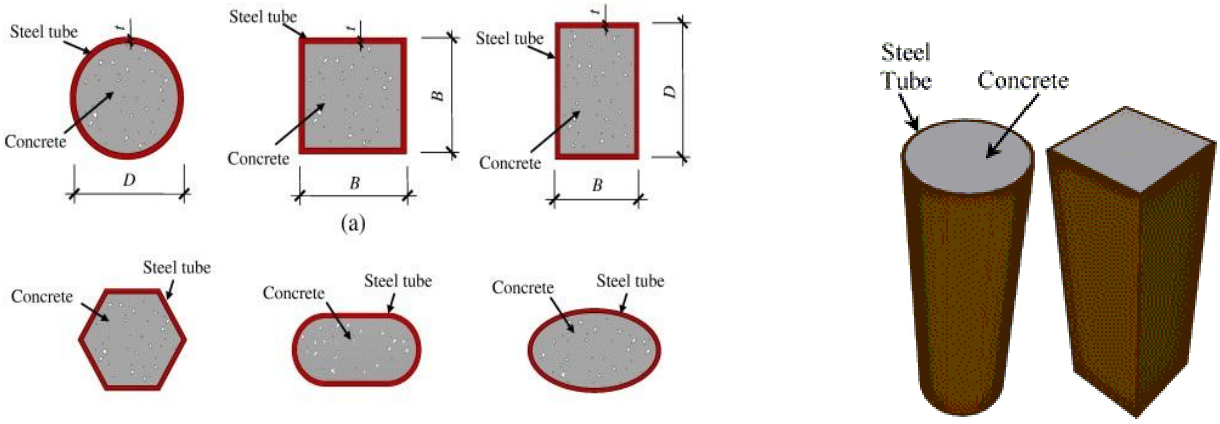


Figure 1.1 CFST Columns

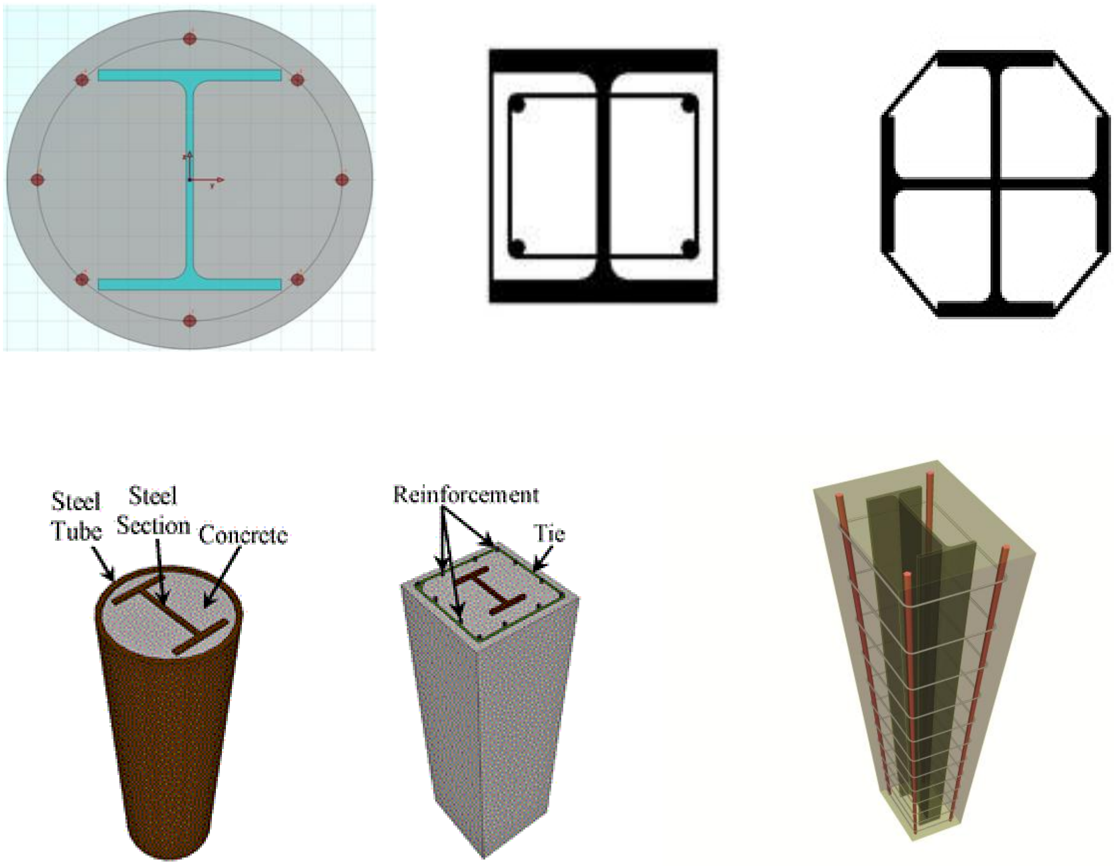


Figure 1.2 Encased Columns

CHAPTER 2

TERMINOLOGY

The various terminologies used in this research are as follows:

(1) Base shear: Base shear is an estimate of the expected maximum lateral force that would occur due to land seismic movement in the structure of the base.

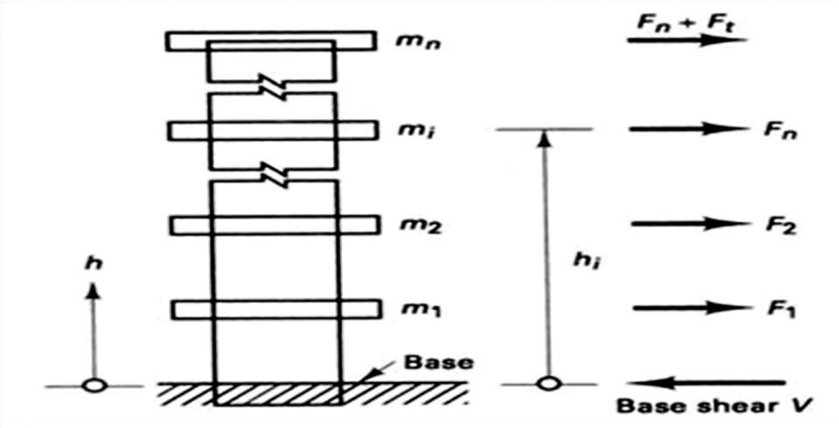


Figure 2.1 Base shear

(2) Storey Drift: Storey drift is the lateral displacement of upper level of building corresponding to the lower level.

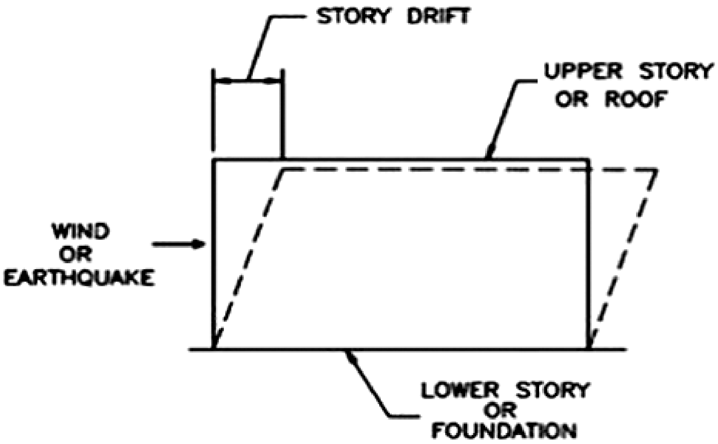


Figure 2.2 Storey Drift

CHAPTER 3

REVIEW OF LITERATURE

The literature review is written depending upon the various researches done by the different researchers. The main factors to be considered for designing, analyzing & differentiating the RCC, Composite and Steel structures are as follows:

3.1 Base shear

A G+5 story building in seismic zone IV is analysed by **Ganwani et. al(2016)[1].** & seismic performances of both RCC and composite materials are compared. It is found that the base shear is more in RCC as compared to the composite frame due to the more seismic weight of RCC frame as represented by Figure.3.1.

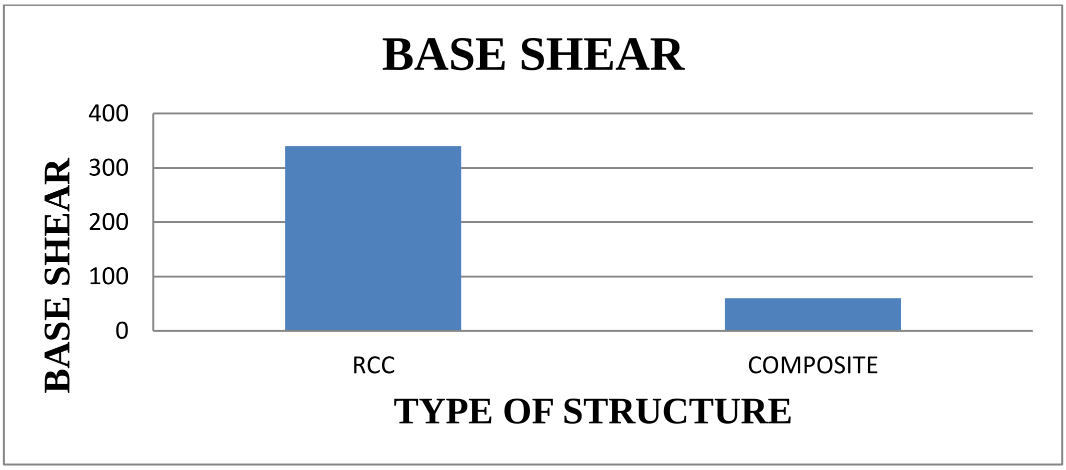


Figure 3.1 Base Shear vs. Building Storey

Kolhe et al.(2015)[2] has performed comparative non-linear Time History Analysis on G+10 story residential buildings of steel & composite materials situated in earthquake zone IV and concluded that base shear is decreased by 10% for steel frame as compared to composite frame. The reason is that weight of composite frame is more than steel frame.

Warade et al.(2013)[3] concluded that the base shear is maximum in case of RCC & minimum in case of steel. The composite found to have more value of base shear than steel but very much less than RCC. Multi-level car parking structure is analysed using seismic co-efficient method. Total 15 models were modeled with RCC, composite & steel, 5 for each material i.e.(G+6,G+7,G+8, G+9,G+10). Reason being as the weight increases, base shear values are also boosted as represented by Figure 3.2.

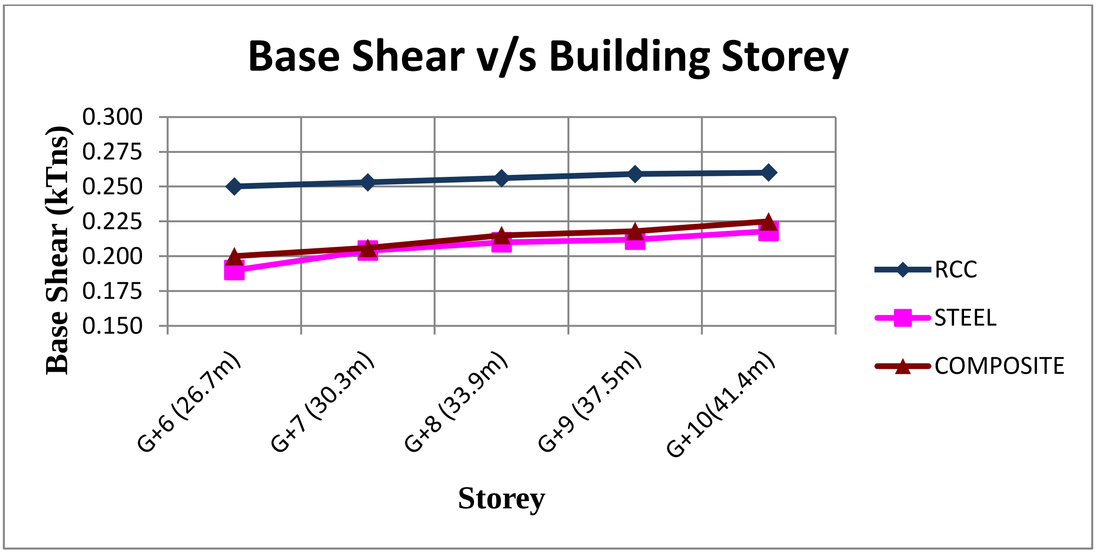


Figure 3.2 Base Shear vs. Type of Structure

3.2 Storey Drift

In a comparative study of Steel and RCC for G+6 & G+10 storey structures **Sangave et al. (2015)[4]** have analyzed for seismic zone V in ETABS. The work concludes that within permissible limits, RCC structures have less values of storey drift in comparison with steel structures. So stiffness is playing the lead role in storey drift factor.

Cholekar et al.(2015)[5] have conducted equivalent static and response spectrum analysis on G+9 storey building located in Zone III, considering mass irregularity and their effects. Their work also shows that the because of stiffness storey drift is low in case of composite structure.

Kolhe et al.(2015)[2], published storey drift results concluding that the composite frames has lowest storey drift values as compared to the steel frames & the only justification for that is the stiffness of composite frame. The variability in storey drift values in X & Y directions is due to the column orientation which leads to the different moments of inertia.

Mohite et al.(2015)[6] have analysed of B+G+11 storey commercial building in their research. The Building is located at Kolhapur which comes under seismic zone III and basic wind speed is 39 m/s in the above said area. The RCC as well as steel-concrete composite frame is considered for equivalent static analysis of building.The storey drift in composite structure resulted in less values in comparison to the RCC structure. So due to increase in stiffness values of the structure the storey drift values goes down and results in good seismic performance of the structure.

3.3 Weight

Charantimath et al.(2014)[7] has analysed three buildings of 10, 20 & 30 storey having dimensions of 30m X 24m. The weight comparison between RCC & composite building is represented in graphical form as shown in Figure 3.3 which shows that composite building is lighter than RCC building. As he no. of stories increases, the difference in weight is also increases.

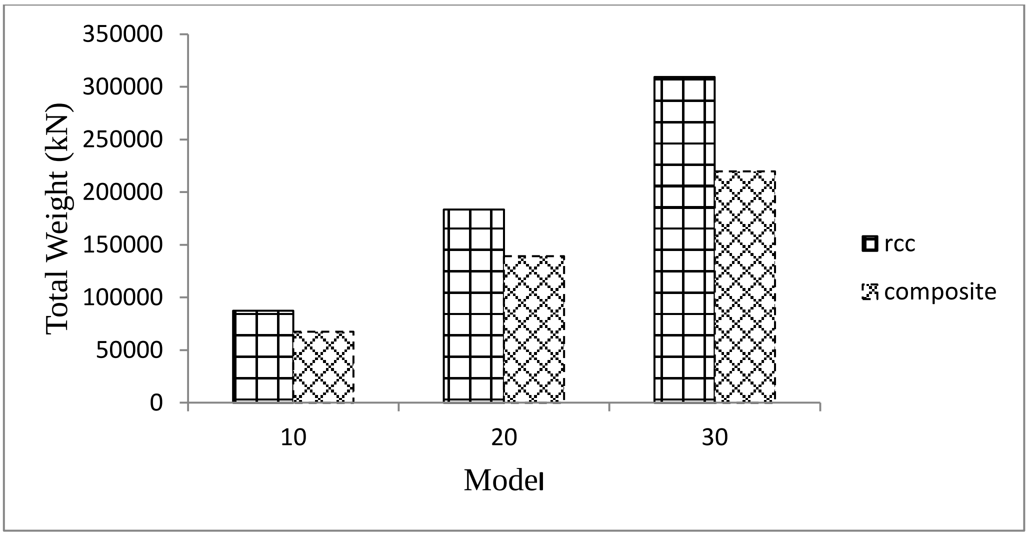


Figure 3.3 Comparison of Total wt. v/s RCC & Composite

Warade et al.(2013)[3], has compared different buildings, their work can be represented as the table of self weights (in kTns) shown below:

Table 3.1 Comparison for Self-weight of the structure of the building

STOREY	**G+6(26.7m)**	**G+7(30.3m)**	**G+8(33.9m)**	**G+9(37.5m)**	**G+10(41.4m)**
RCC	10.53	11.86	13.19	14.52	15.86
STEEL	7.74	8.73	9.72	10.69	11.68
COMPOSITE	8.04	9.06	10.07	11.09	12.11

Panchal et al.(2011)[8], has compared self weight for the RCC, Steel and composite G+30 storey commercial building. RCC structure found to have more weight more weight than other two and steel having least weight. Their work can be represented as the table below:

Table 3.2 Self weight of building with respect to material

BUILDING TYPE	RCC	STEEL	COMPOSITE
Self Weight (kN)	368168	248397	256354

3.4 Cost

Wagh et al.(2014)[9] have done the comparative study of RCC & steel-concrete composite structures. The four multistoried buildings are considered. The cost estimation is done using the MS-Excel software and results are compared. The result shows that the composite structure is economical & lighter as compared to RCC construction. The results are shown as bar chart in Figure 3.4.

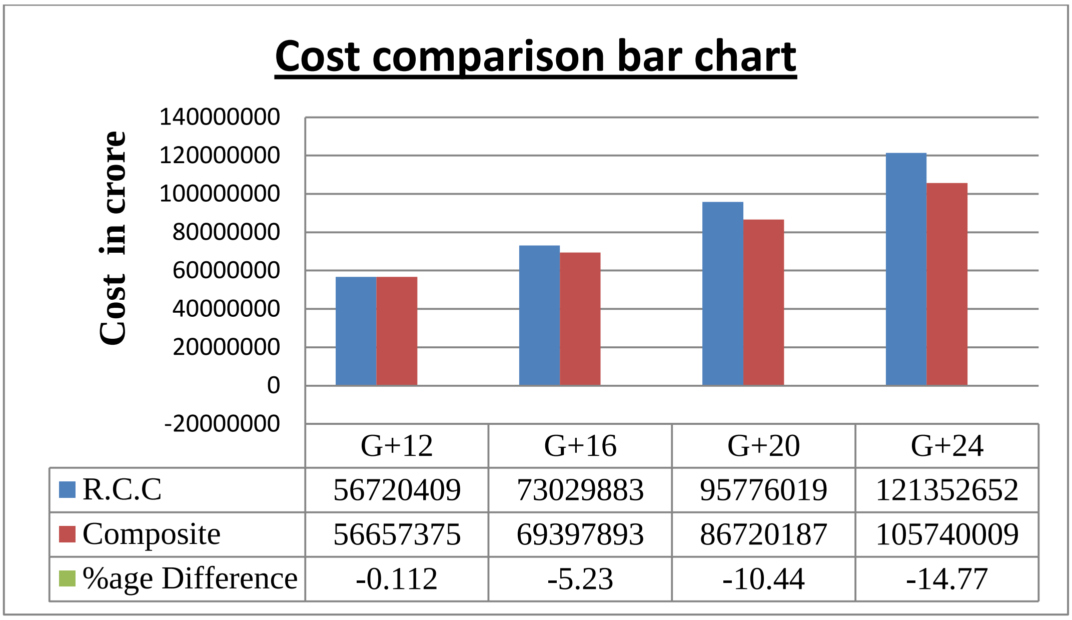


Figure 3.4 Cost Comparison Bar Chart

Prajapati et al.(2013)[10] have studied the seismic & wind effects on multi storey RCC, steel & composite buildings. The G+30 storey building is analyzed under the effect of wind load & earthquake load. The cost comparison is done for seven models [(Steel), (Steel+Bracing), (Steel Secondary Beam Composite), (Steel Secondary Beam Composite +Bracing), (Steel All Beam Composite), (Steel All Beam Composite +Bracing), (R.C.C)] & SABC model is more economic in comparison to other models. The graphical representation of results is as follows:

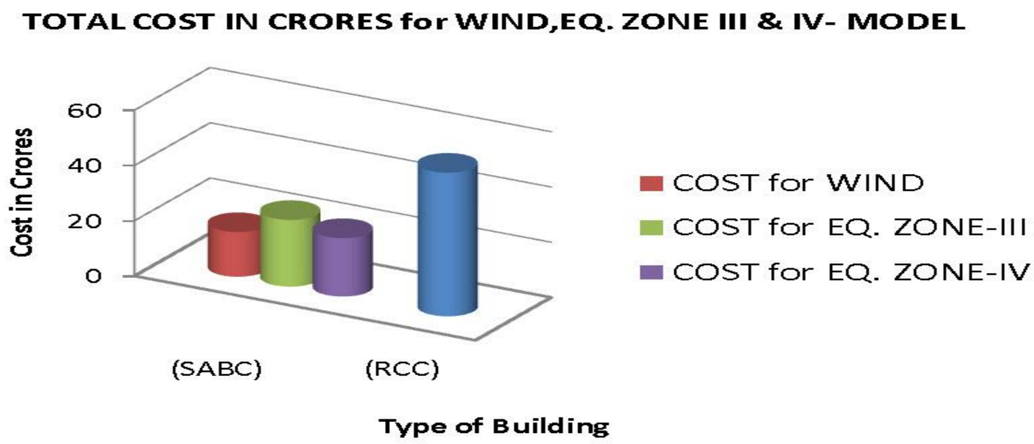


Figure 3.5 Total Cost v/s Type of Building Graph

Begum et al.(2013)[11] have compared cost of RCC & steel-concrete composite structure and found that cost of steel-concrete composite structure is more in case of low rise buildings up to 15th storey but high for medium rise buildings to high rise buildings the cost of steel-concrete structure is less as compared to RCC structure. The final results shows that for the buildings having no. Of storey more than 15, steel-concrete composite construction is very economical as compared to the RCC construction. The cost comparison graph is as Figure 3.6.

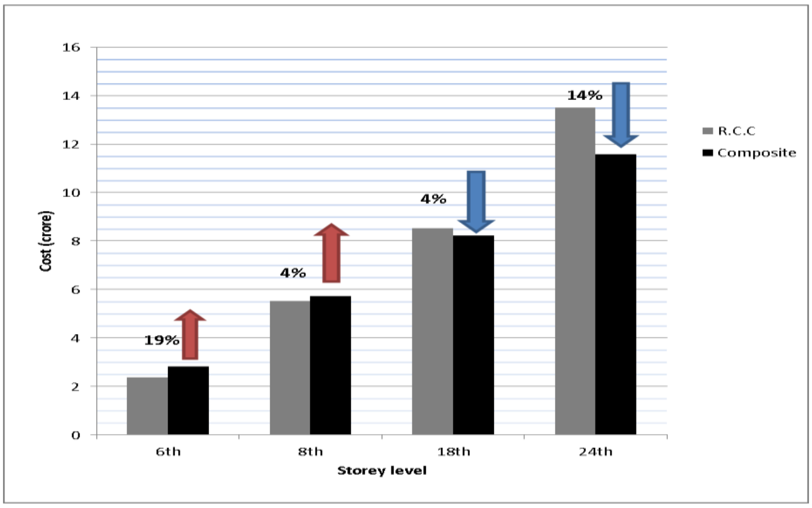


Figure 3.6 Cost comparison bar chart

3.5 Maximum Shear Forces, Bending Moments, Axial Forces and Nodal Displacements

Koppad et al.(2013)[12] have done the relative study of B+G+15 storey of residential building situated in seismic zone III considering RCC & steel-concrete composite options. STAAD.Pro V8i software is used for analysis & design. Axial forces variations, maximum shear force, maximum bending moments & displacements variations are prepared for both RCC & steel-concrete composite structure. Due to the more flexibility of the composite structure, the **nodal displacements** in composite structure are more.

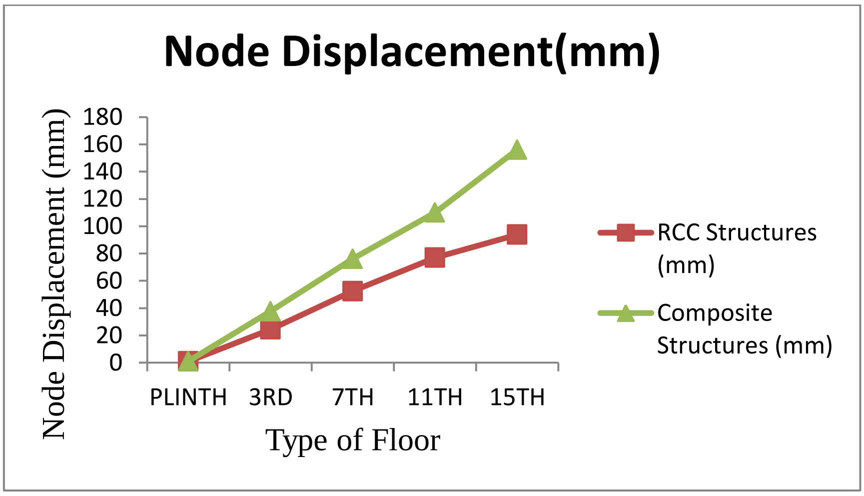


Figure 3.7 Nodal Displacements V/s Type of Floor Graph

Panchal et al.(2011)[8], have find the relative results of shear force & bending moment in beams & axial forces in columns for G+30 storey building. The office building having the dimensions of 24 m x 42 m located in Zone IV. **The axial forces** decreases with reduction in weight of members.

Table 3.3 : Columns Axial Forces In KN

	RCC	STEEL	COMPOSITE
Ground Floor to 10th floor	22051.9	11668.3	17365.0
		47% reduction	21.5% reduction
10th Floor to 20th floor	14061.1	7665.2	17360.0
		45.4% reduction	23% increase
20th Floor to 30th floor	6970.7	3850.7	5625.0
		44.8% reduction	20% reduction

The results for **maximum bending moment and shear force** in main beams are as follows:

Table 3.4 : Shear Forces In Main Beams

	RCC	STEEL	COMPOSITE
Ground Floor to 10th floor	390.35	1169.86	554.96
		200% increase	42% increase
10th Floor to 20th floor	332.7	557.63	631.19
		67% increase	89% increase
20th Floor to 30th floor	233.86	534.73	634.88
		128% increase	171% increase

Table 3.5 : Bending Moments in Main Beams

	RCC	STEEL	COMPOSITE
Ground Floor to 10th floor	704.3	1839.8	1322.9
		161% increase	87% increase
10th Floor to 20th floor	585.5	2127.1	1217.0
		263% increase	108% increase
20th Floor to 30th floor	474.5	2119.0	1227.2
		346% increase	158% increase

CHAPTER 4

SCOPE & OBJECTIVES OF STUDY

- The present study aids in deciding the four major aspects of building construction that are briefly discussed below.

I. **Building Type (Low Rise, Medium Rise & High rise)**

The present study attempts to include all the three types of buildings i.e. Low, Medium & High rise for the purpose of comparison. Thus after completion of this study it will be easier to decide which type of building is to be constructed under various conditions.

II. **Seismic & Wind Location**

The buildings that falls under Seismic Zone IV according to IS-1893 is considered in this study. Other zones i.e. Zone II and III. are not considered because buildings under Seismic Zone IV are more vulnerable to earthquake hazards as compared to Zone II and III. The Wind speed at building location is 47m/s which is also critical especially in case of taller buildngs. So, better results can be found for both loads from this study.

III. **Cost**

The next important factor to be considered in designing and construction is the cost of building and it is often seen that whenever a cheaper option is available the cheaper is preferred than other (costlier) design or idea. Thus optimal selection of cost related attributes like material selection, formwork selection and speed and ease of construction will be aided with this study.

IV. **Weight**

Weight of structure will affect the cost of foundation, building and ground improvement expenses and it (weight) depends entirely upon the type of material used in constructing one. As in case of RCC structure the weight of building is more especially in case of high rise buildings. So criteria for material selection can be selected by keeping in mind the results of this study.

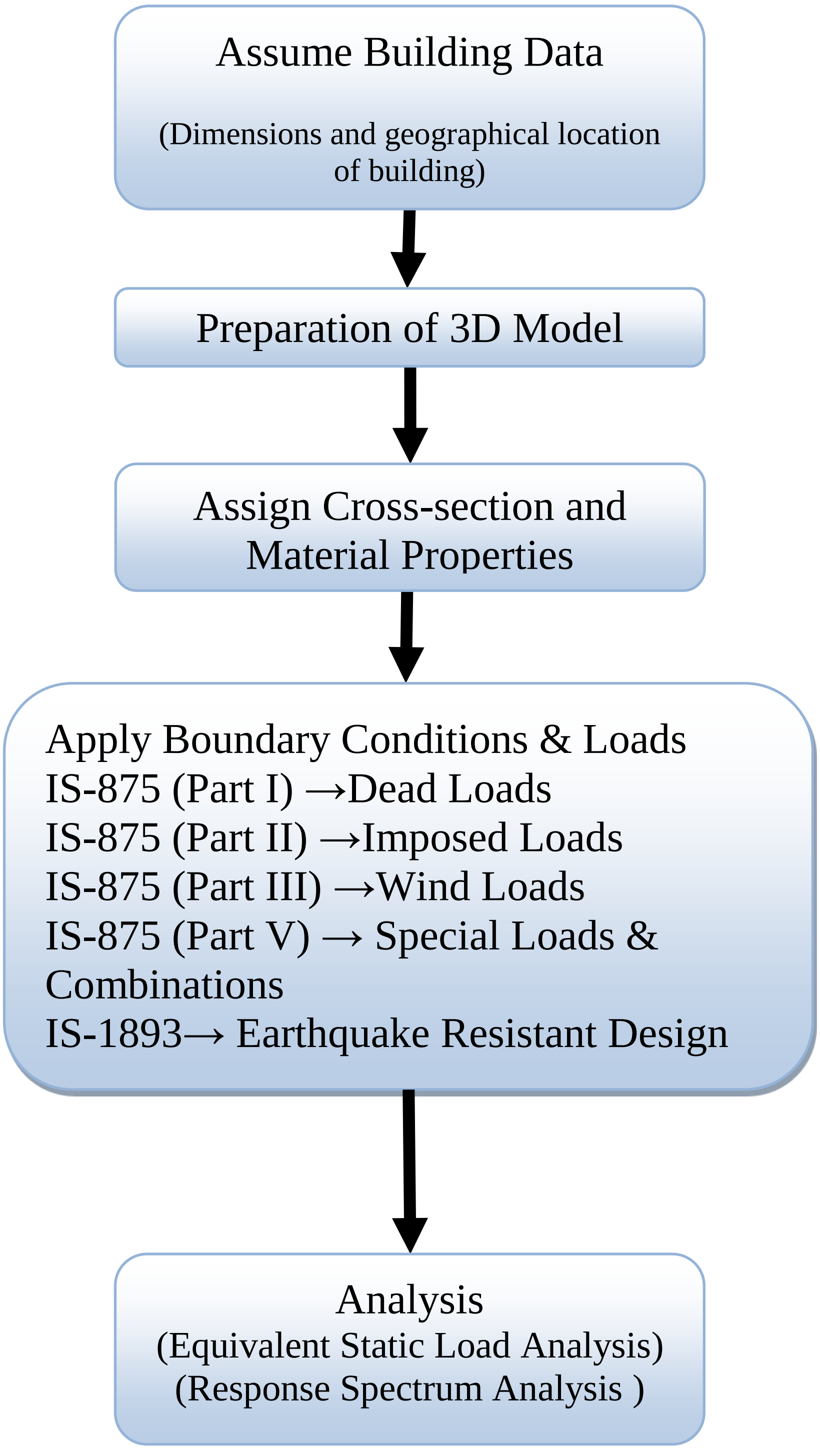
- Apart from above mentioned points the present study also attempts to introduce and promote **Steel-Concrete Composite Construction** in India which will lead to technological advancements in the country which is equally important.

Parameters like storey drift, wind effects, storey displacement and seismic response of S-C Composite frames are calculated with the help of ETABS software suite.

CHAPTER 5

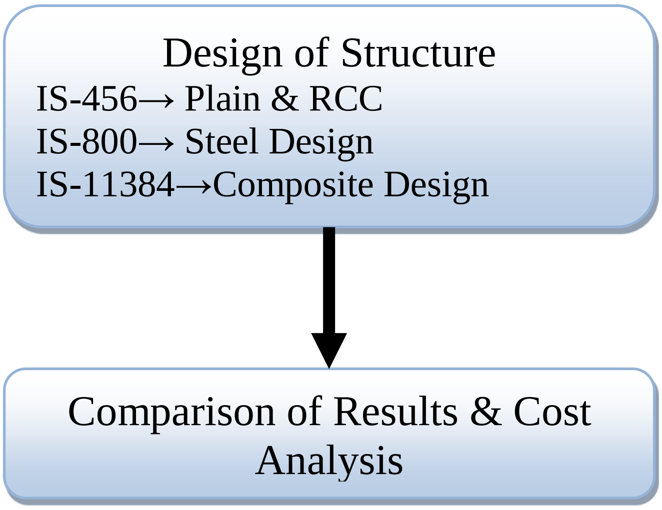
MATERIALS & RESEARCH METHODOLOGY

The methodology adopted for current research is represented by flowchart given below.



Continued on Next Page....

Continued from Last Page….



The present work done includes the analysis of RCC frame, steel frame & composite frame by equivalent static load analysis & Response spectrum analysis . The low-rise building of 11 story, medium rise building of 21 story and high rise building of 31 story is considered for the analysis. The building data detail for these three type of buildings is represented below:

Table 5.1 Building Data For Low Rise Building

Building Dimension In X- Direction	36 m
Building Dimension In Y- Direction	20 m
Building Height	33 m
No. Of Story	11
Typical Storey Height	3 m
Building Location	Bhiwadi, Rajasthan.

Table 5.2 Building Data For Medium Rise Building

Building Dimension In X- Direction	36 m
Building Dimension In Y- Direction	20 m
Building Height	63 m
No. Of Story	21
Typical Storey Height	3 m
Building Location	Bhiwadi, Rajasthan.

Table 5.3 Building Data For High Rise Building

Building Dimension In X- Direction	36 m
Building Dimension In Y- Direction	20 m

Building Height	93 m
No. Of Story	31
Typical Storey Height	3 m
Building Location	Bhiwadi, Rajasthan.

After the collection of building data for all the three types of structures, the three dimensional model is prepared in ETABS 2015 with the help of various modeling tools. The Plan view of building is represented as follows:

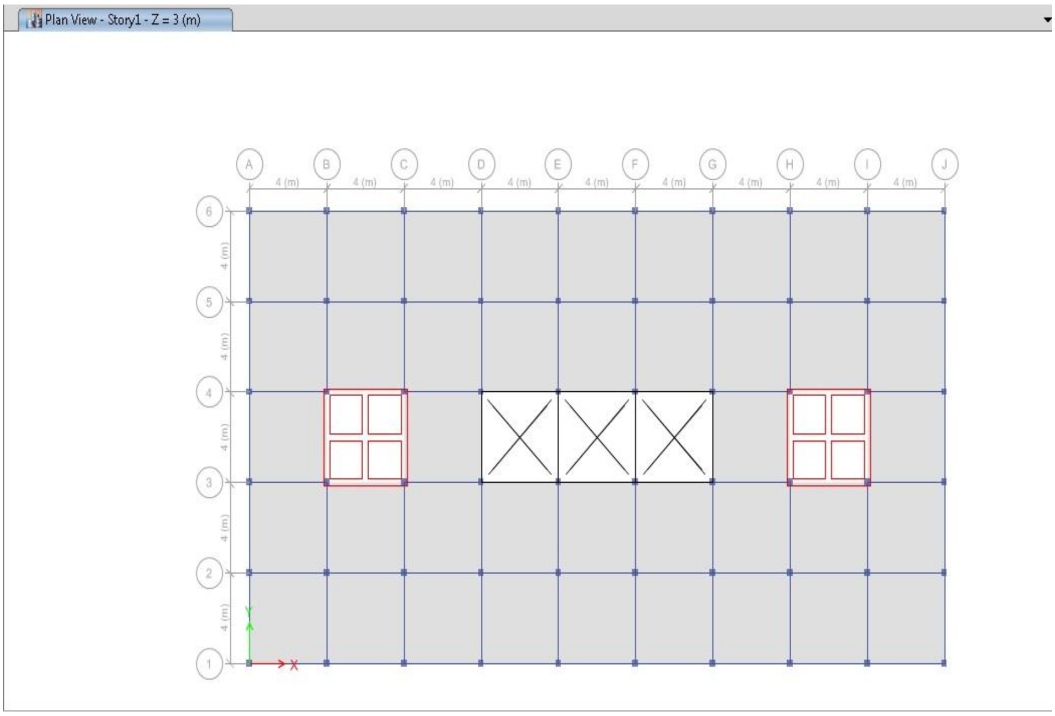


Figure 5.1 Top View Of Building

The material properties considered for the analysis of buildings is shown as below:

Table 5.4 Material Properties Used

Unit Weight Of R.C.C.	25 KN/m³
Unit Weight Of Steel	79 KN/m³
Grade Of Concrete	M30
Grade Of Reinforcing Steel	HYSD500
Grade Of Structural Steel	Fe 345
Modulus Of Elasticity For R.C.C. (M30)	27.386 KN/m²
Modulus Of Elasticity For Steel	210 KN/m²

The cross section properties used in analysis of low, medium & high rise buildings are shown in following tables:

Table 5.5 Cross Section Properties Used For 11 Storey Structure

CROSS SECTION PROPERTIES			
Member	**RCC**	**Steel**	**Composite**
Beam	230mm x 400mm	ISWB 500	ISWB 550
Column	300mm x 300mm	ISHB 300-1 with 12mm thick & 300mm wide cover plates attached to both flanges	Filled Steel Tube 300mmx300mm with 10mm flange & web thickness
Slab Thickness	150mm	150mm	150mm
Shear Wall Thickness	300mm	300mm	300mm

Table 5.6 Cross Section Properties Used For 21 Storey Structure

CROSS SECTION PROPERTIES			
Member	**RCC**	**Steel**	**Composite**
Beam	230mm x 400mm	ISWB 550	ISWB 550
Column (Ground Floor To 10th Floor)	600mm x 600mm	ISHB 400-1 with 12mm thick & 300mm wide cover plates attached to both flanges	Filled Steel Tube 500mmx500mm with 10mm flange & web thickness
Column (11th Floor To 21st Floor)	400mm x 400mm	ISHB 350-2 with 12mm thick & 300mm wide cover plates attached to both flanges	Filled Steel Tube 400mmx400mm with 10mm flange & web thickness
Slab Thickness	150mm	150mm	150mm
Shear Wall Thickness	300mm	300mm	300mm

Table 5.7 Cross Section Properties Used For 31 Storey Structure

CROSS SECTION PROPERTIES			
Member	**RCC**	**Steel**	**Composite**
Beam	230mm x 450mm	ISWB 600-1	ISWB 600-1
Column (Ground Floor To 10th Floor)	800mm x 800mm	ISHB 400-1 with 20mm thick & 350mm wide cover plates attached to both flanges	Filled Steel Tube 500mmx500mm with 18mm flange & web thickness
Column (11th Floor To 20th Floor)	600mm x 600mm	ISHB 350-1 with 20mm thick & 300mm wide cover plates attached to both flanges	Filled Steel Tube 400mmx400mm with 16mm flange & web thickness
Member	**RCC**	**Steel**	**Composite**
Column (21st Floor To 31st Floor)	400mm x 400mm	ISHB 300-1 with 20mm thick & 300mm wide cover plates attached to both flanges	Filled Steel Tube 400mmx400mm with 14mm flange & web thickness
Slab Thickness	150mm	150mm	150mm
Shear Wall Thickness	300mm	300mm	300mm

The loads considered in an structure are mainly of two types.

1) Basic loads
2) Lateral loads

Basic loads includes dead load and live load. While lateral loads are mainly the earthquake loads and wind loads. In this research, seismic load is considered for zone IV as per IS codes So wind load is taken according to wind speed 47m/s in that particular location.. The intensities of basic loads and seismic loads parameters are as explained in tables below:

Table 5.8 Basic Loads Considered

Basic loads	
Dead load	self weight
Screed + flooring + partitions wall +False ceiling & HVAC load	3KN/m²
Live load	3 KN/m²

Table 5.9 Seismic Load Parameters Considered

Seismic loads parameters		
Direction	x and y with no eccentricity	
Response reduction factor	5	
Seismic zone	IV	
Seismic zone factor	0.24	
Site type	II	
Importance factor	1.5	
Time period	**X**	**Y**
Low Rise Building	0.495	0.664
Medium Rise Building	0.945	1.268
High Rise Building	1.395	1.871

Table 5.10 Wind Load Parameters Considered

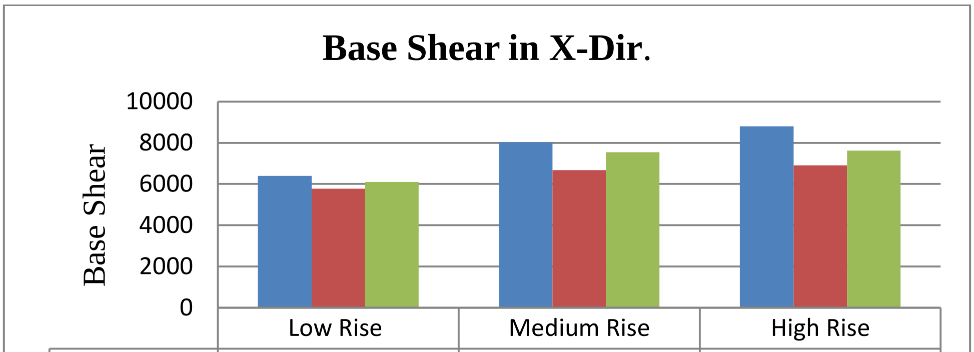
Wind loads parameters	
Wind Speed	47m/s
Terrain Category	2
Structure Class	B
Risk Coefficient(k1 Factor)	1
Topography (k1 Factor)	1

CHAPTER 6

RESULTS AND DISCUSSIONS

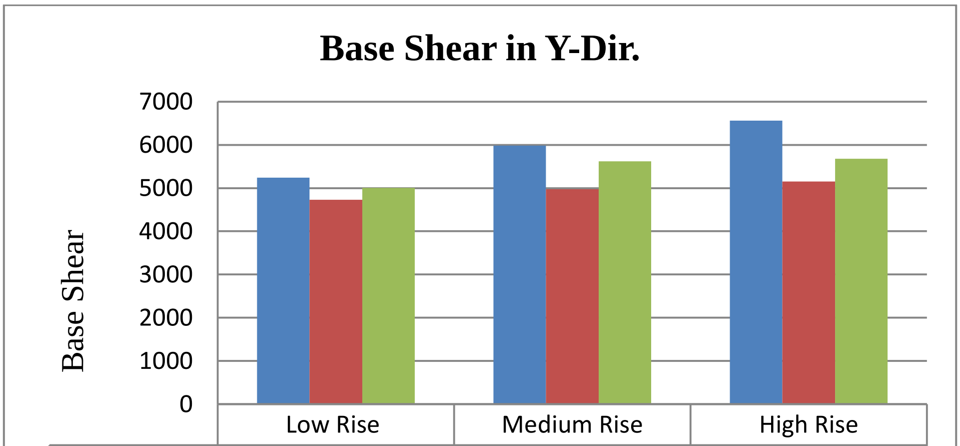
Equivalent static load analysis method & Response Spectrum Method is conducted on low rise, high rise and medium rise structures.. The base shear, maximum storey displacements in the structure, Storey Drift, Mode versus Time Period, Mode versus Frequency and Cost analysis, these all parameters are studied and comparison of these is done as below:.

6.1 BASE SHEAR:



	Low Rise	Medium Rise	High Rise
RCC	6394.4252	8024.7302	8797.9203
STEEL	5774.2394	6677.6647	6908.8899
COMPOSITE	6103.4105	7535.818	7613.3344

Figure 6.1 Comparison of Base Shear in X-Direction



	Low Rise	Medium Rise	High Rise
RCC	5238.8062	5980.5757	6559.6466
STEEL	4730.7022	4976.6507	5151.2033
COMPOSITE	5000.3845	5616.205	5676.4305

Figure 6.2 Comparison of Base Shear in Y-Direction

1) **In case of low rise buildings**, the base shear is increased by 9.69% in X- direction & Y-direction for RCC, and 5.39% in X- direction & Y-direction for Composite as we compare them with Steel frame.

2) **In case of Medium rise buildings** the base shear is increased by 16.79% in X- direction & Y-direction for RCC, and 11.39% in X- direction & Y-direction for Composite as we compare them with Steel frame.

3) **In case of High rise buildings**, the base shear is increased by 21.47% in X- direction & Y-direction for RCC, and 9.25% in X- direction & Y-direction for Composite as we compare them with Steel frame.

6.2 MAXIMUM STOREY DISPLACEMENTS :

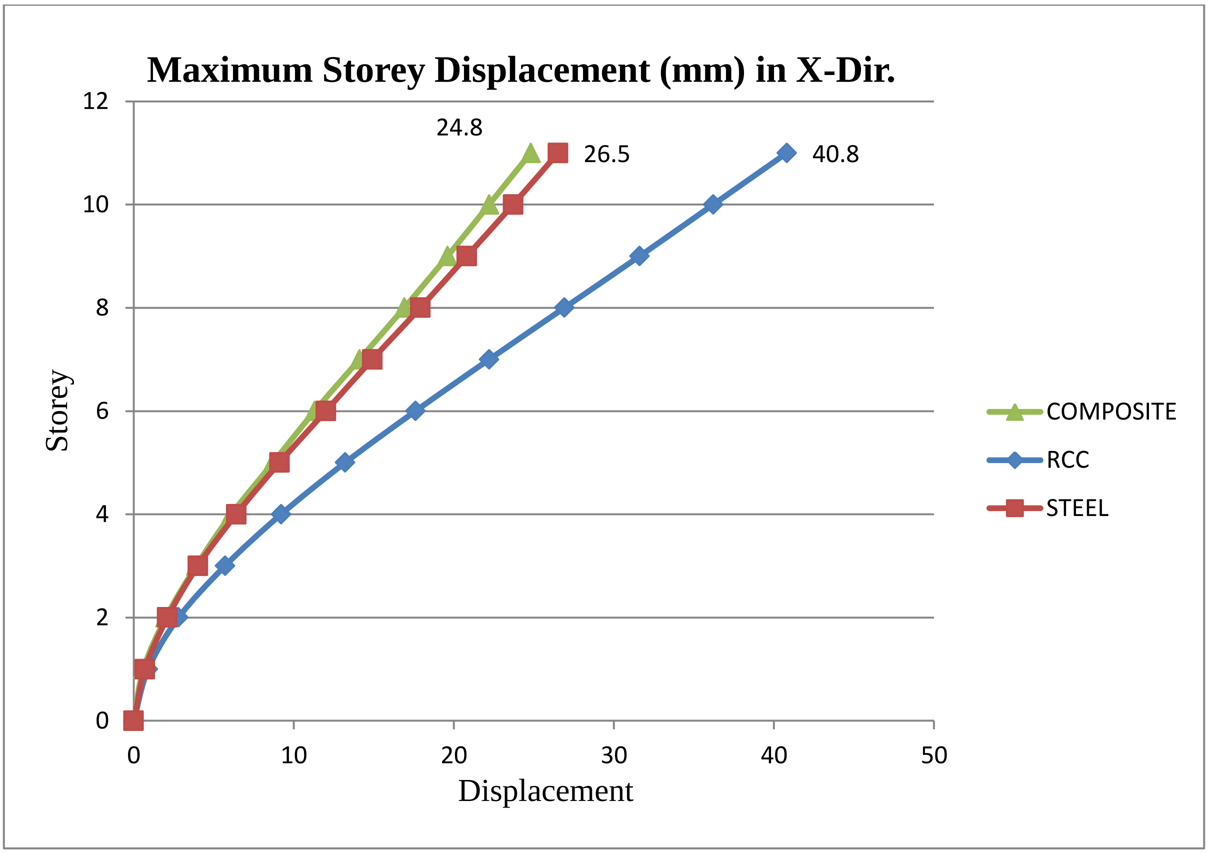


Figure 6.3 Maximum Storey Displacements in X- Direction In Case Of Low Rise Building

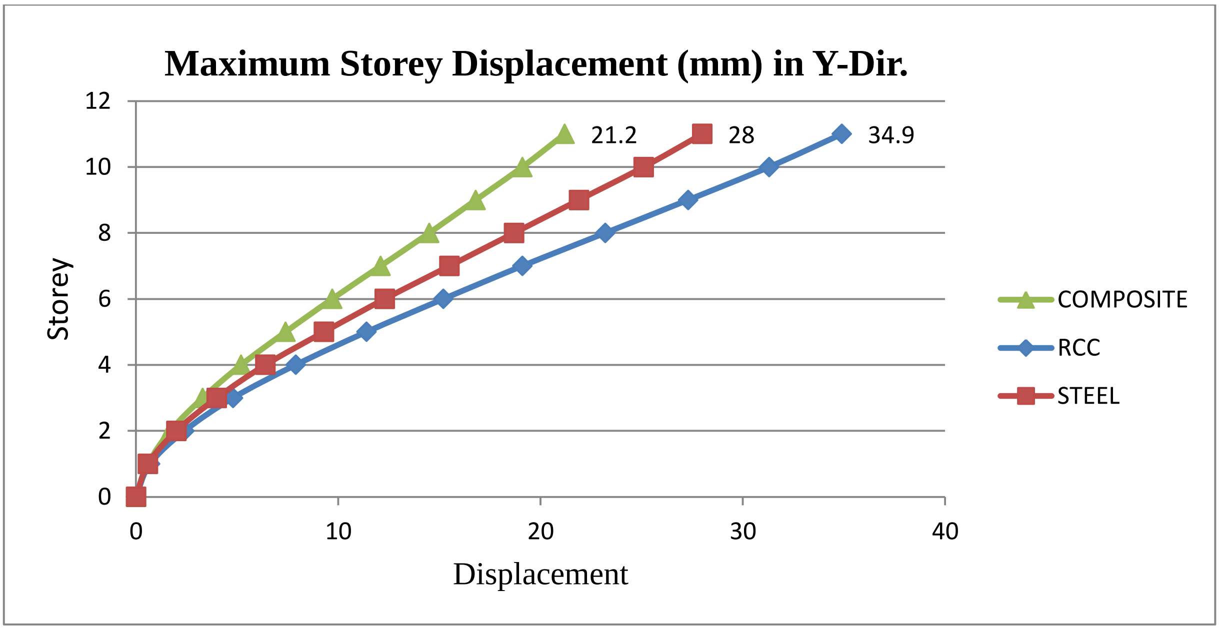


Figure 6.4 Maximum Storey Displacements in Y- Direction In Case Of Low Rise Building

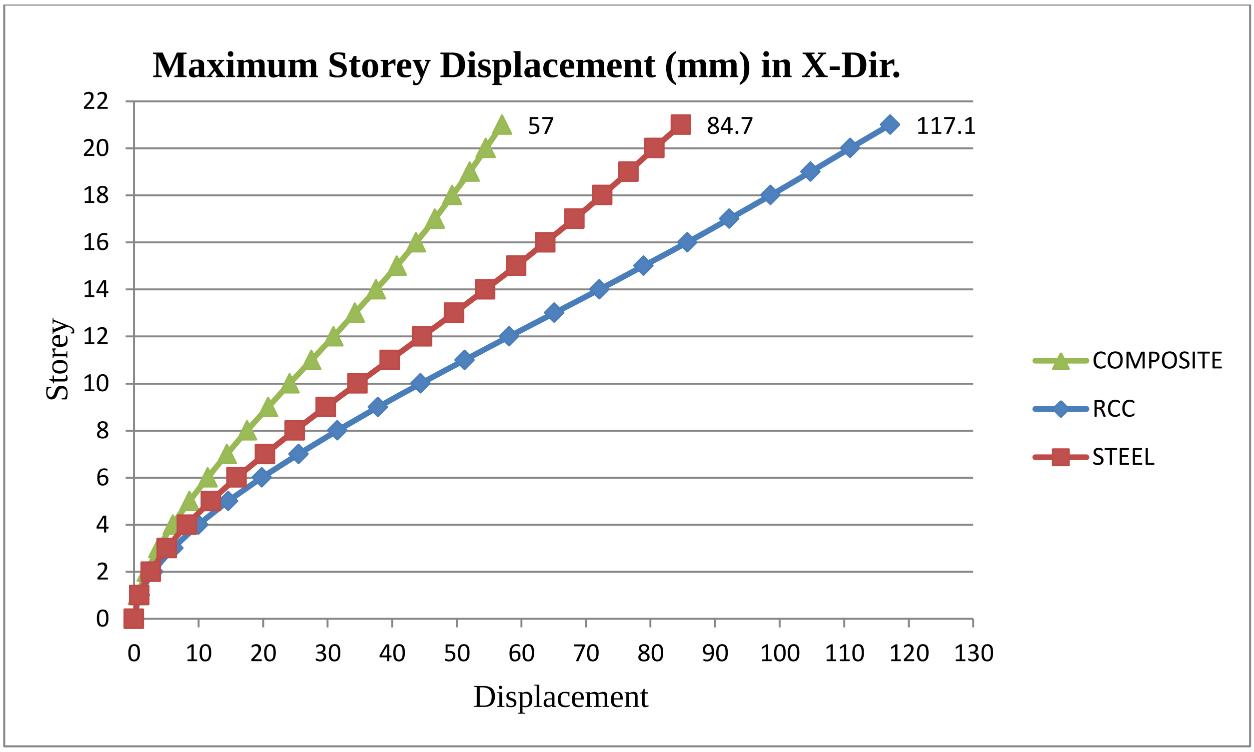


Figure 6.5 Maximum Storey Displacements in X- Direction In Case Of Medium Rise Building

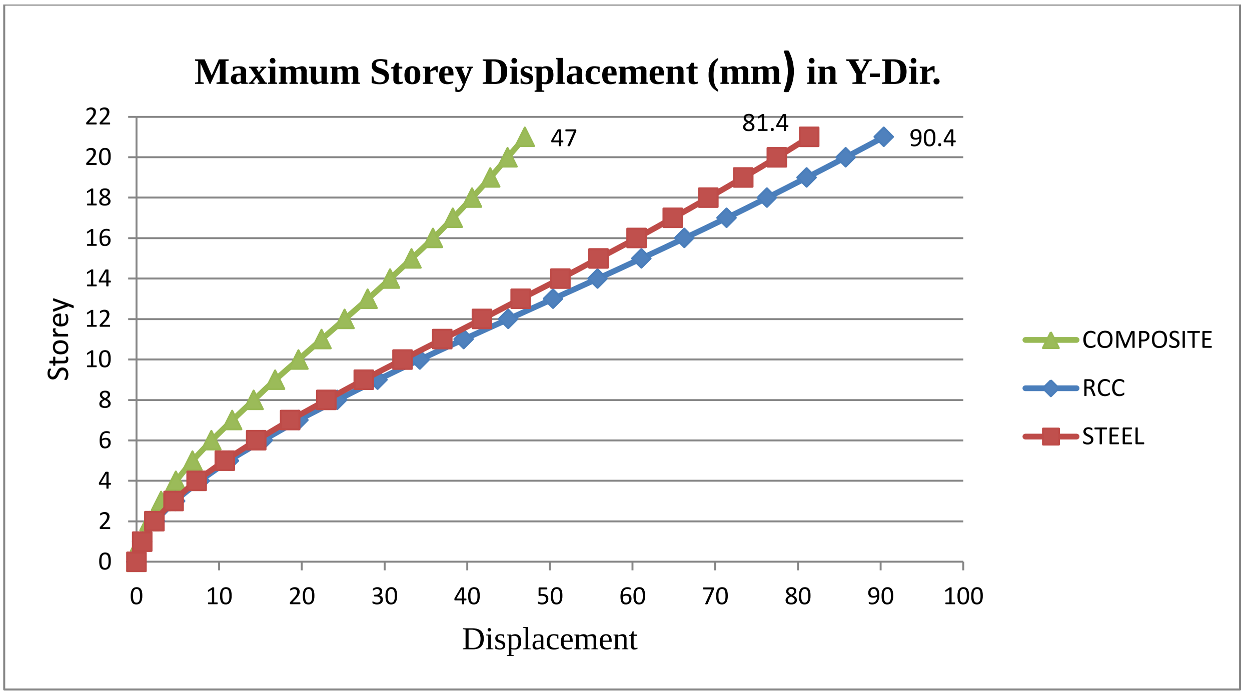


Figure 6.6 Maximum Storey Displacements in Y- Direction In Case Of Medium Rise Building

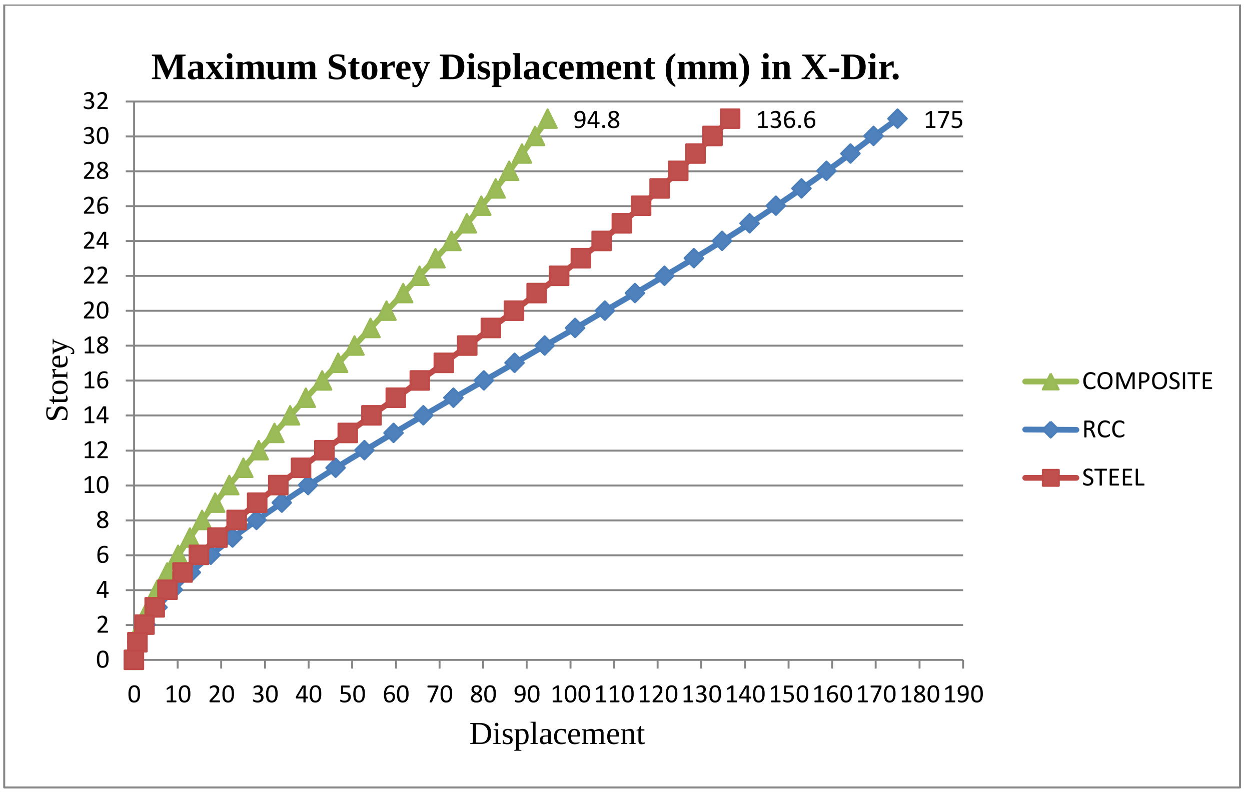


Figure 6.7 Maximum Storey Displacements in X- Direction In Case Of High Rise Building

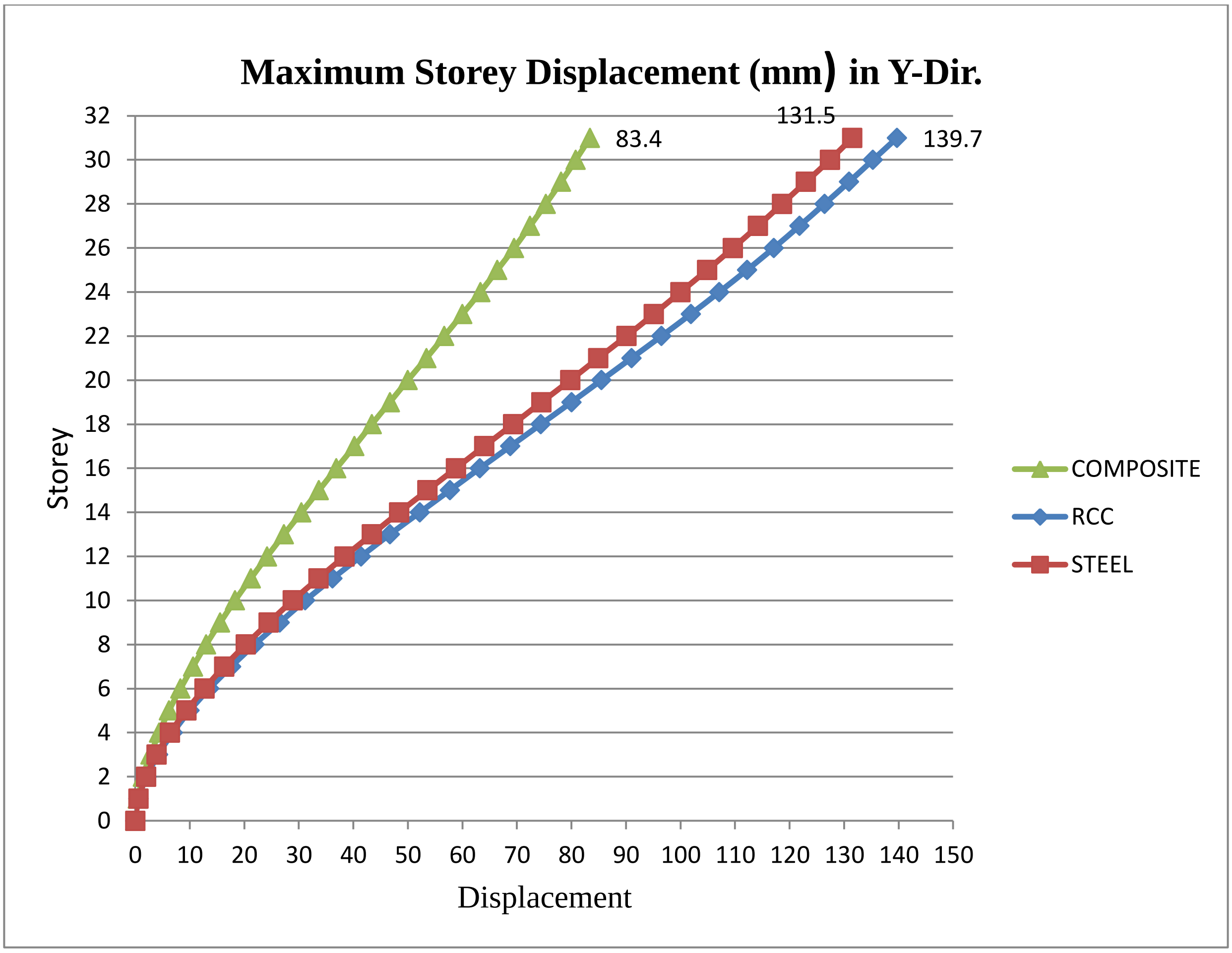


Figure 6.8 Maximum Storey Displacements in Y- Direction In Case Of High Rise Building

1) **In case of low rise buildings**, the maximum story displacements are increased by 6.41% in X-direction & 24.28 % in Y-direction for Steel and 39.21% in X-direction & 39.25 % in Y-direction for RCC as we compare them with composite frame.

2) **In case of Medium rise buildings,** the maximum story displacements are increased by 36.24% in X-direction & 42.26 % in Y-direction for Steel and 53.88% in X-direction & 48% in Y-direction for RCC in comparison with Composite frame.

3) **In case of High rise buildings**, in steel frame the increment in maximum story displacements is 30.6% and 36.58% in X-direction & Y-direction respectively and in RCC frame, the increment in maximum story displacements is 45.83% and 40.3% in X-direction and Y-direction respectively when compared to composite frame.

6.3 MAXIMUM STOREY DRIFTS:

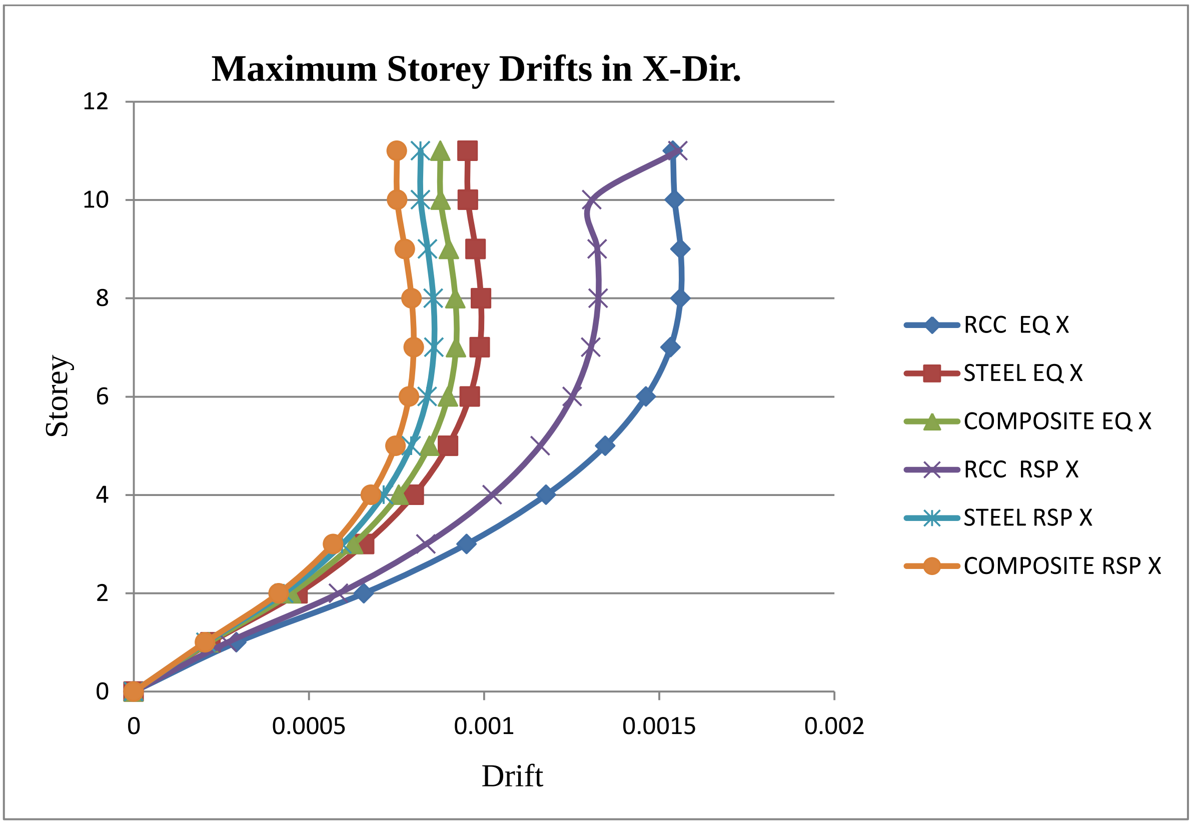


Figure 6.9 Maximum Storey Drifts in X- Direction In Case Of Low Rise Building

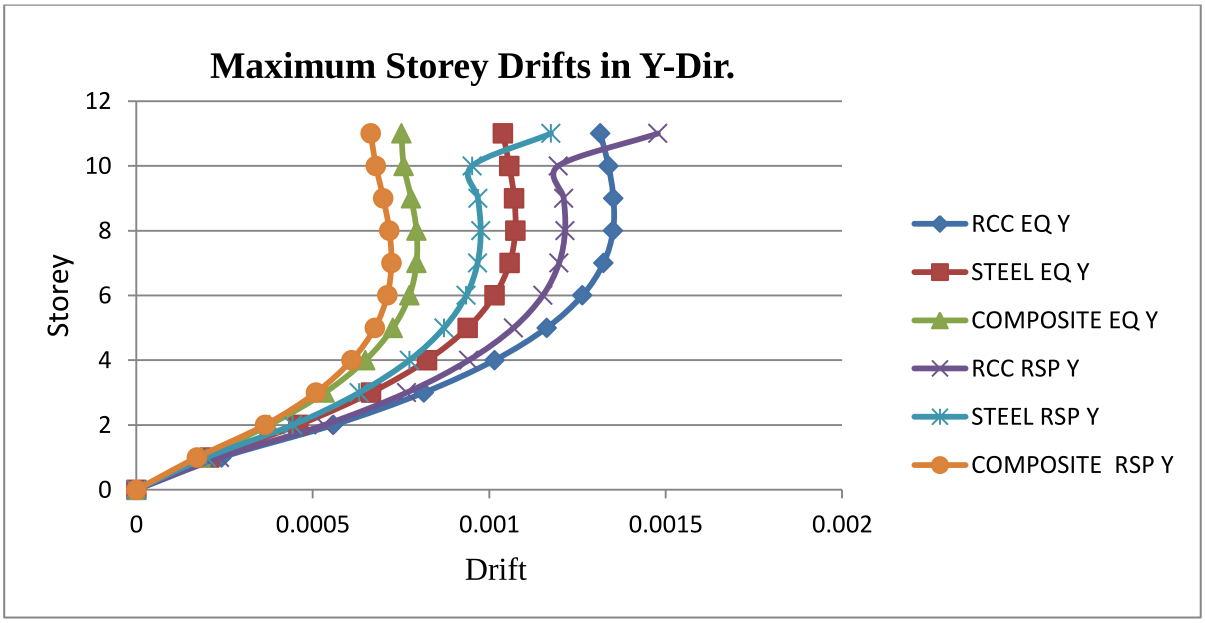


Figure 6.10 Maximum Storey Drifts in Y- Direction In Case Of Low Rise Building

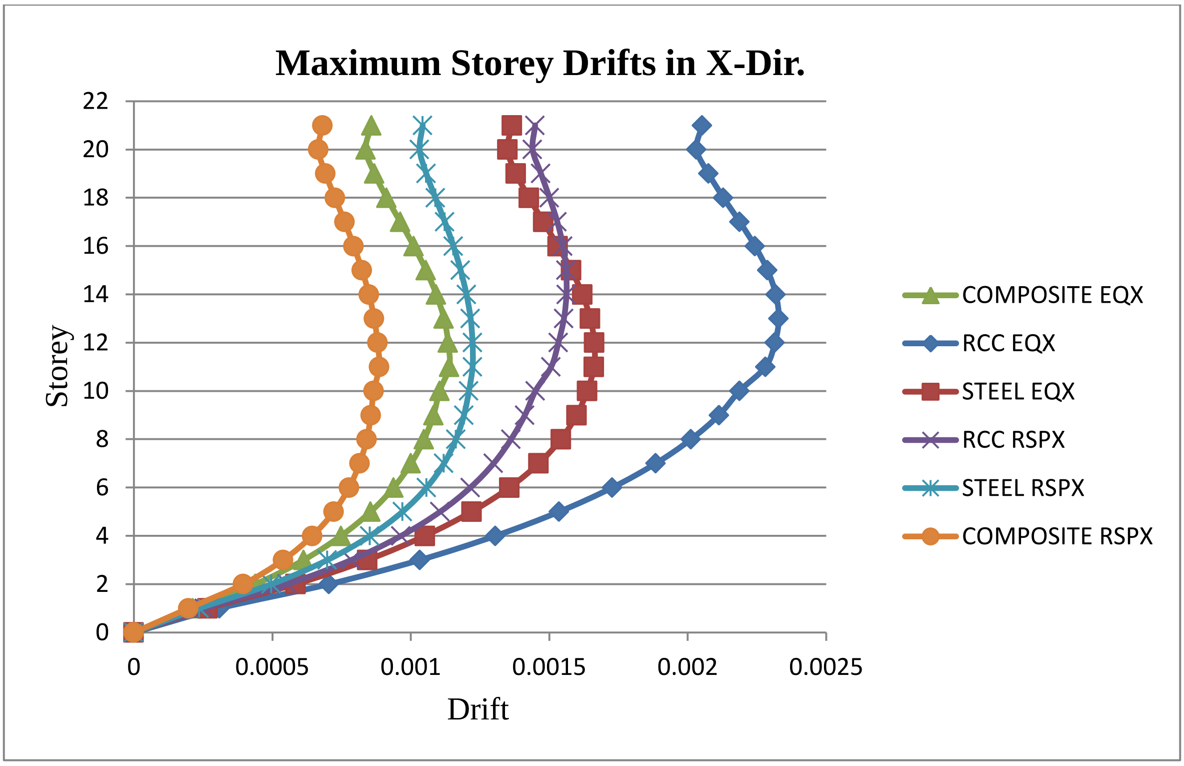


Figure 6.11 Maximum Storey Drifts in X- Direction In Case Of Medium Rise Building

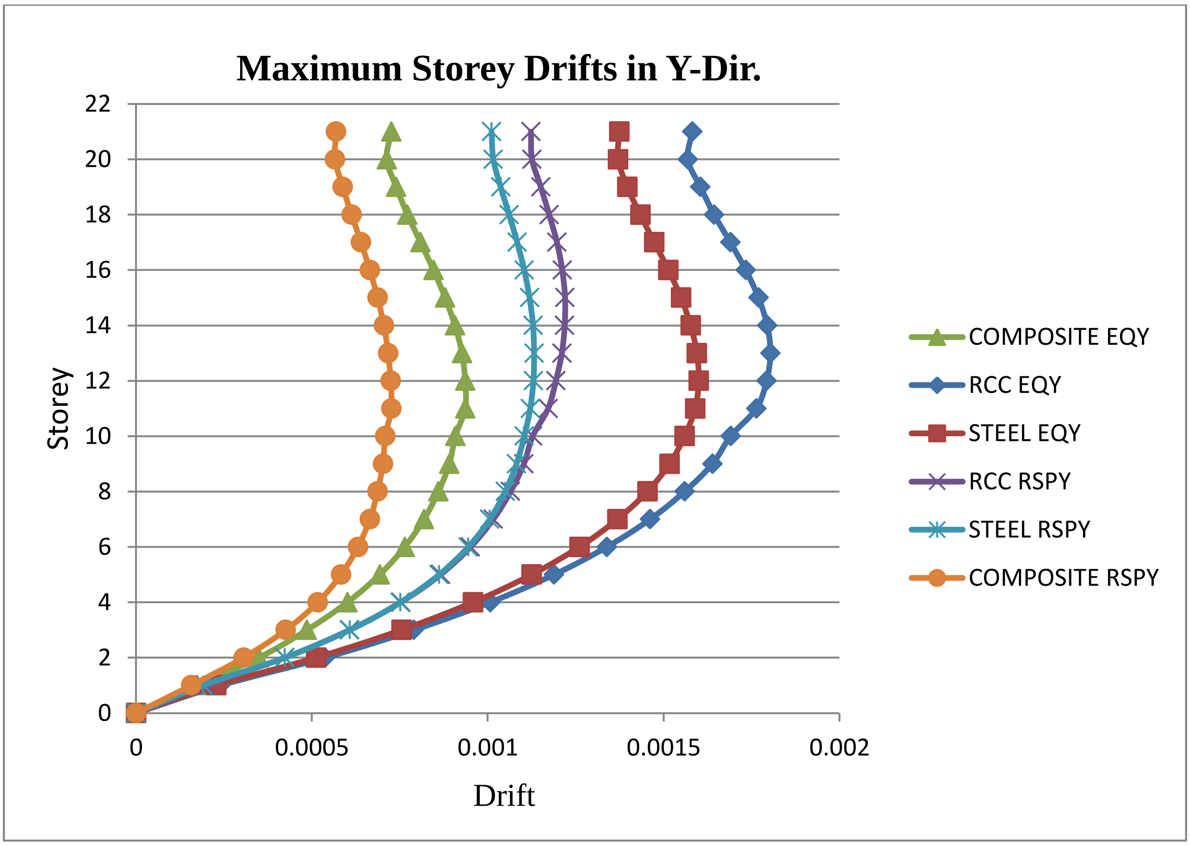


Figure 6.12 Maximum Storey Drifts in Y- Direction In Case Of Medium Rise Building

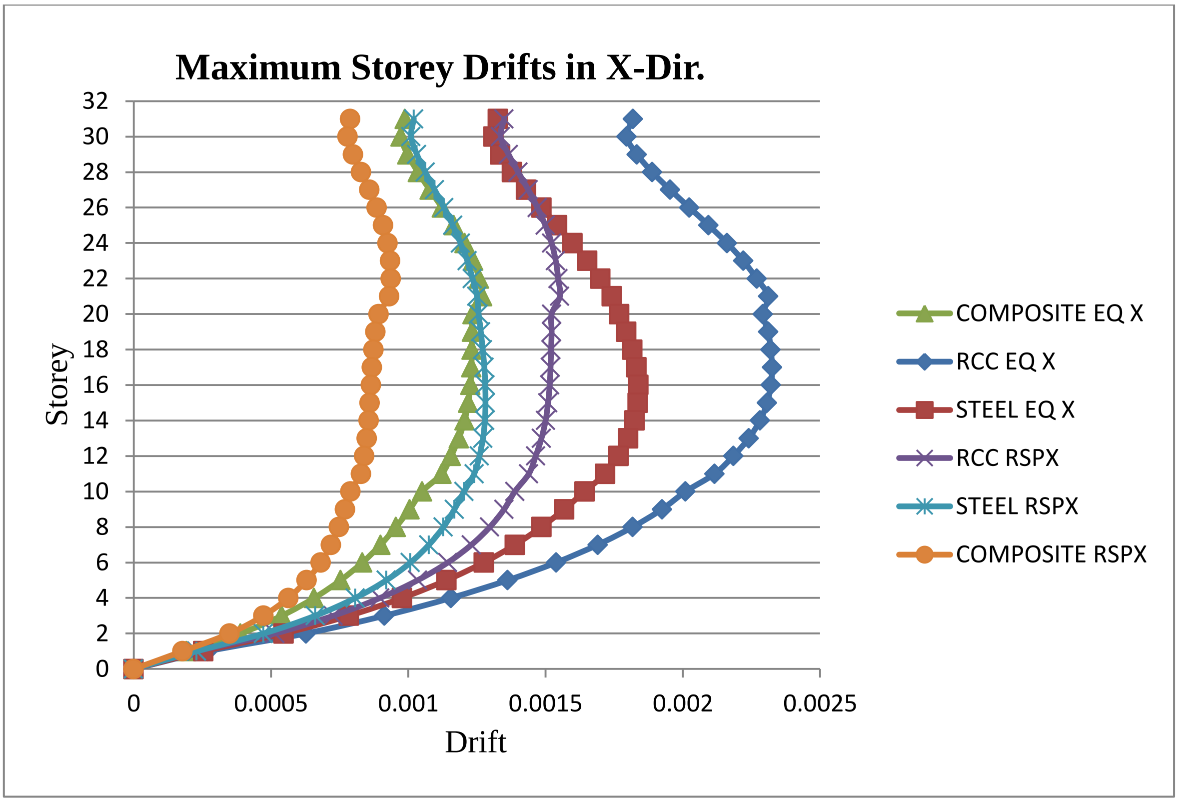


Figure 6.13 Maximum Storey Drifts in X- Direction In Case Of High Rise Building

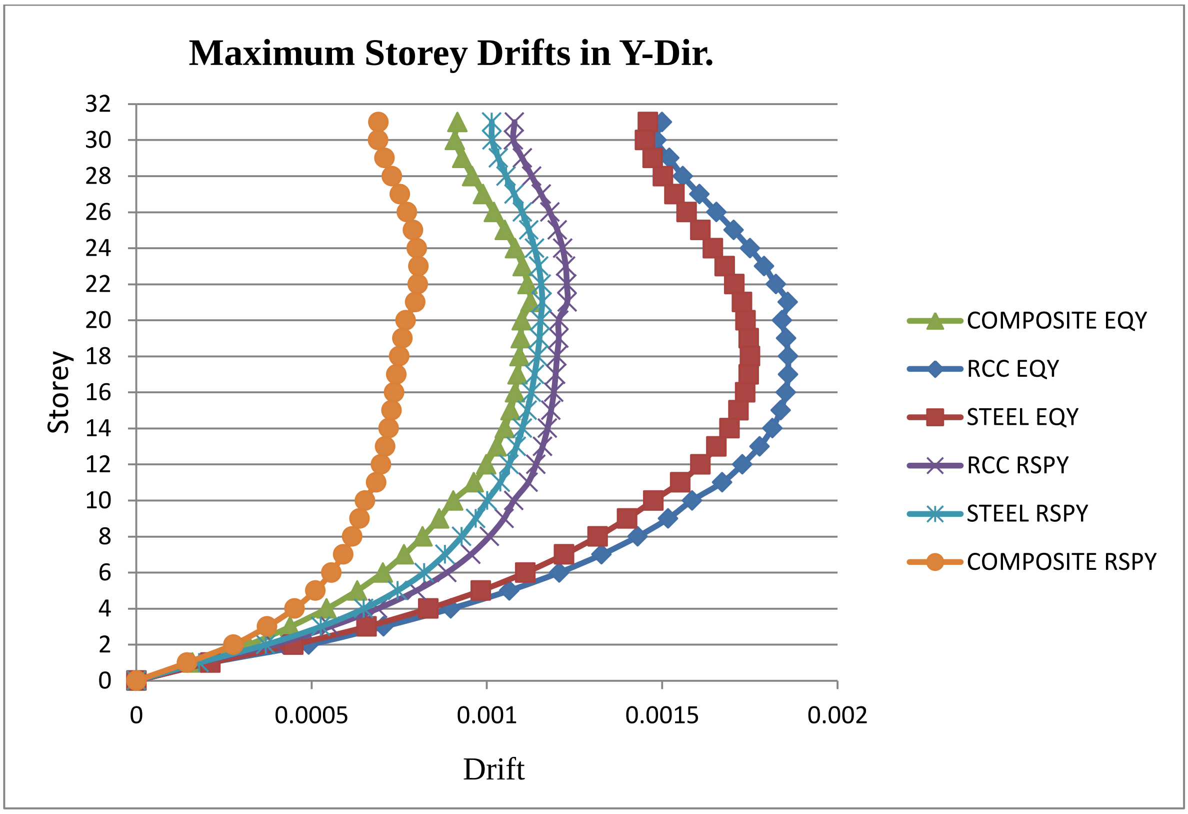


Figure 6.14 Maximum Storey Drifts in Y- Direction In Case Of High Rise Building

In all the three cases the maximum storey drifts having lowest values in composite structure due to response spectrum & due to seismic load in comparison to steel and RCC structure.

6.4 TIME PERIOD:

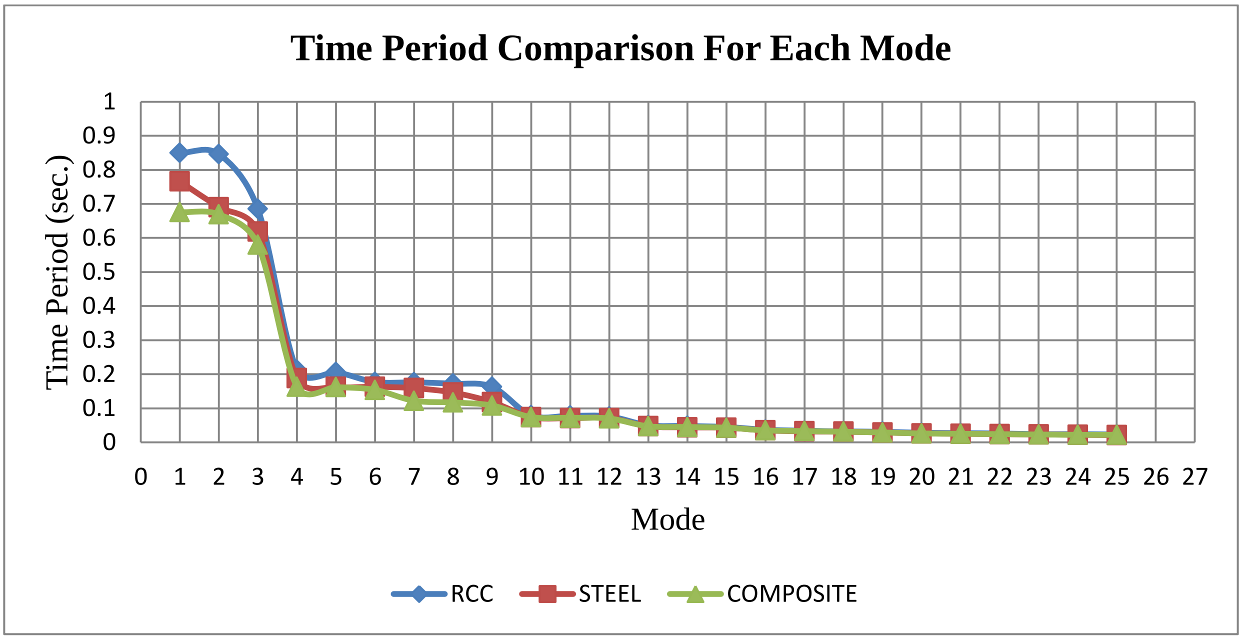


Figure 6.15 Time Period Comparison For Each Mode in Case Of Low Rise Building

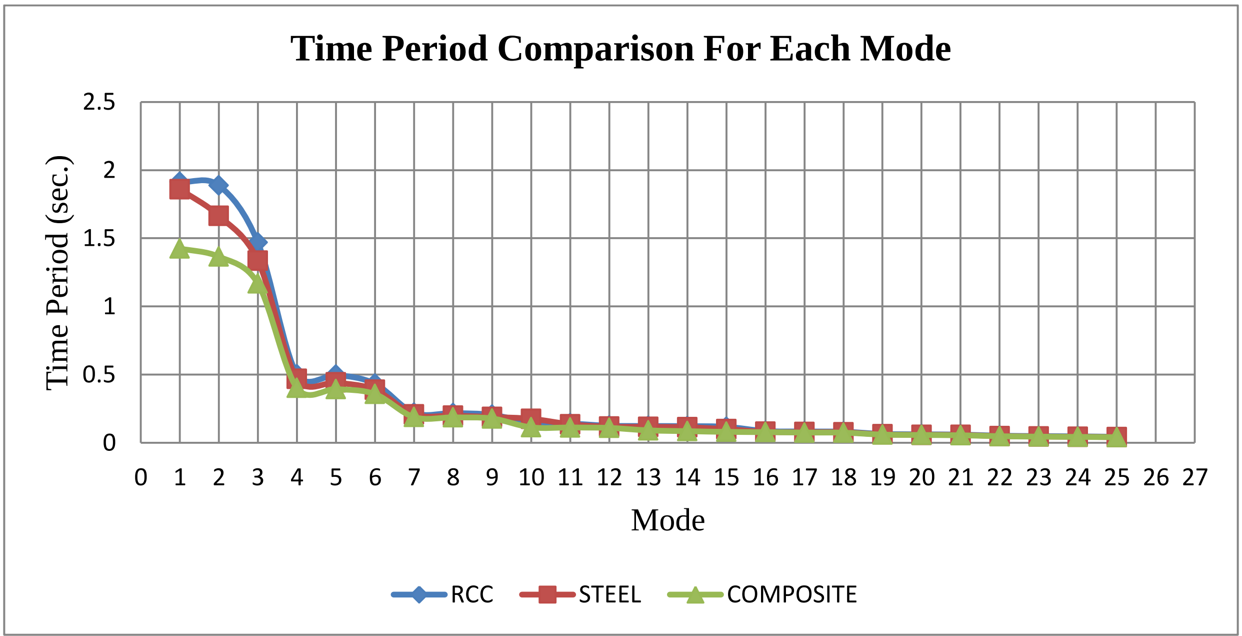


Figure 6.16 Time Period Comparison For Each Mode in Case Of Medium Rise Building

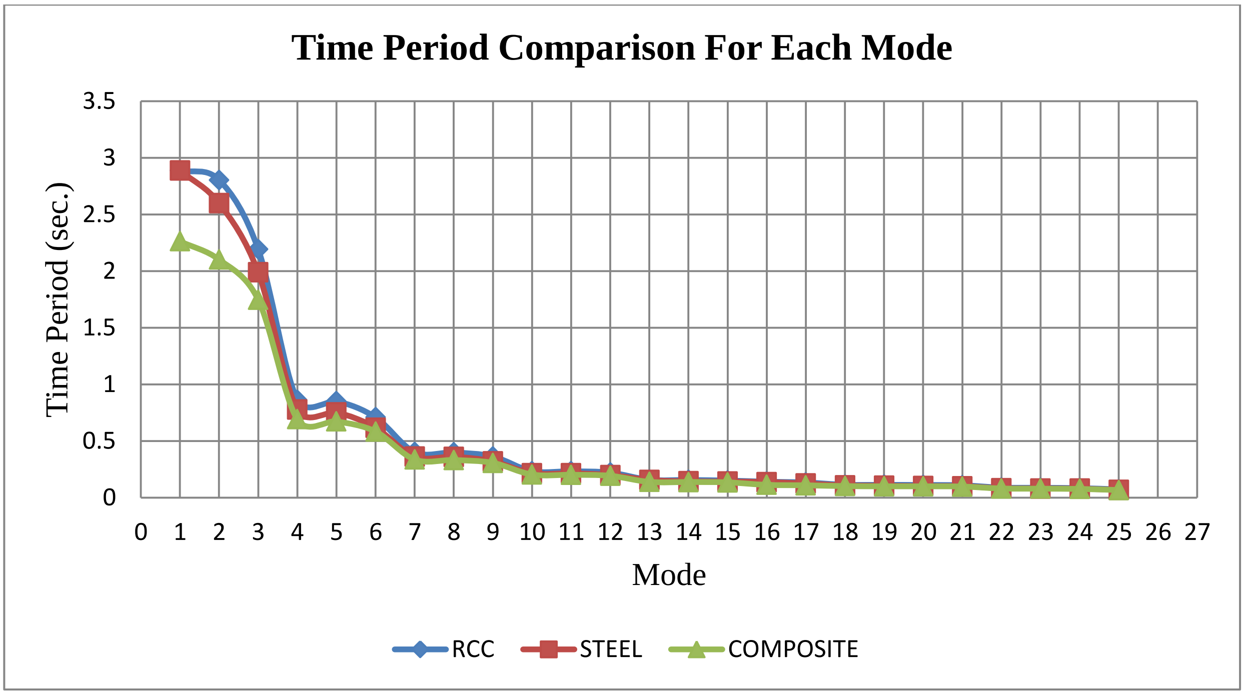


Figure 6.17 Time Period Comparison For Each Mode in Case Of High Rise Building

6.5 MODAL FREQUENCY:

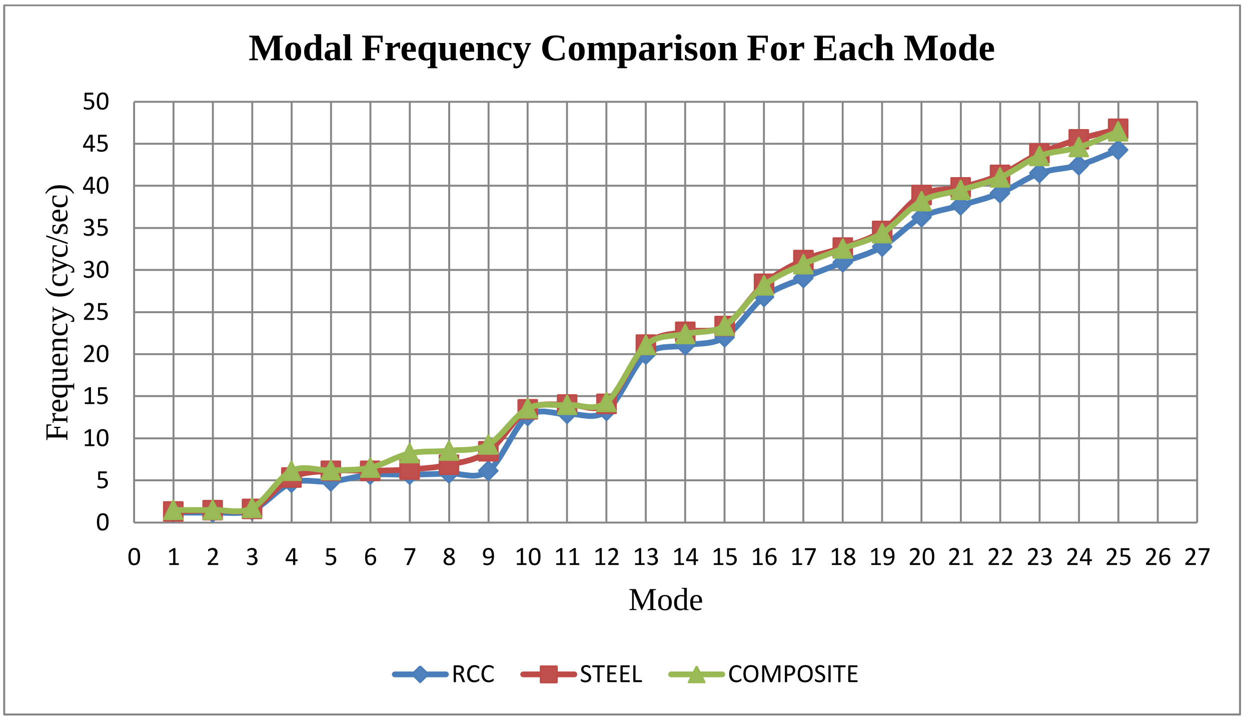


Figure 6.18 Comparison of Frequency For Each Mode in Case Of Low Rise Building

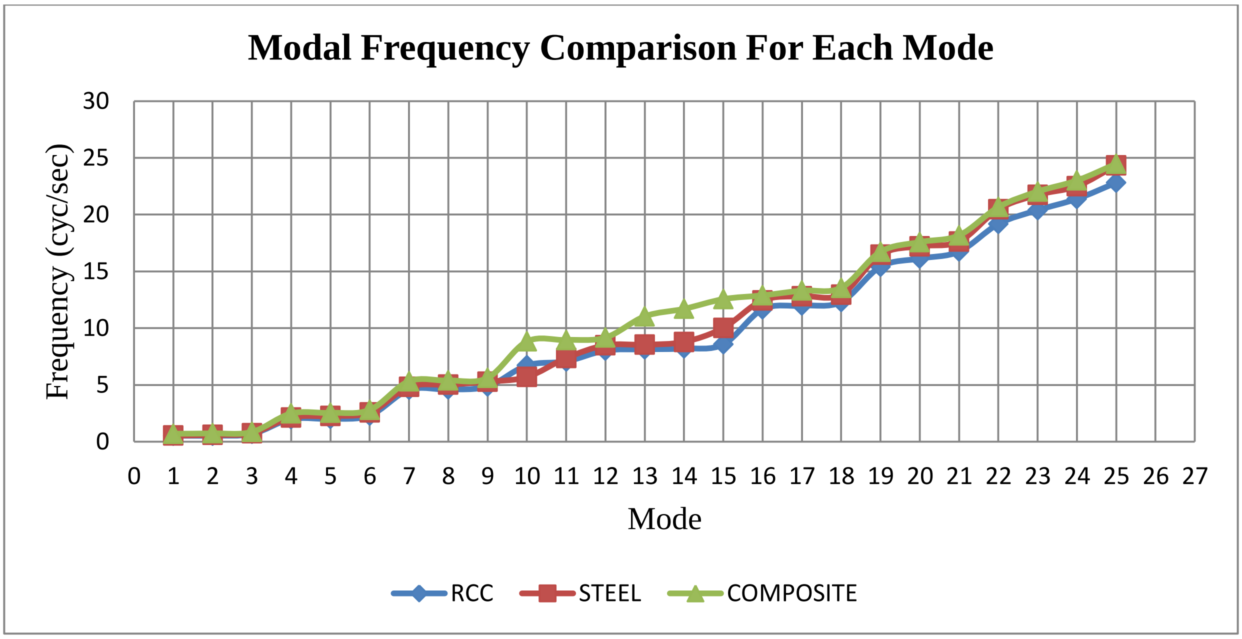


Figure 6.19 Comparison of Frequency For Each Mode in Case Of Medium Rise Building

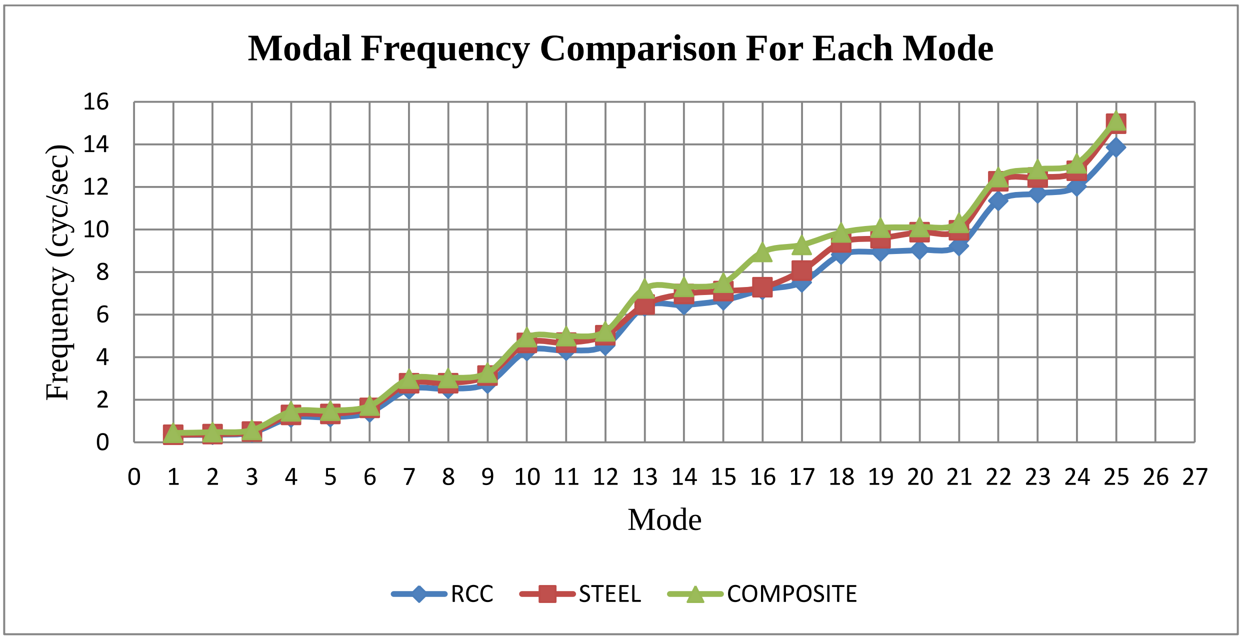


Figure 6.20 Comparison of Frequency For Each Mode in Case Of High Rise Building

The frequency of composite structure is increased and time period of composite structure is decreased due to the increased stiffness of composite structure.

6.6 COST ANALYSIS:

Cost Comparison of materials used in Beams & Columns of RCC, steel & composite frame structure is done using the Microsoft Excel Software. Etabs only gives the concrete quantity of concrete and structural steel (i.e. fabricated steel). For the calculation of reinforcing steel in beams, MS- Excel program is used. Only an approximate amount of cost is calculated .The results shows that the RCC beam & column members having the lowest cost in comparison with steel and composire structures. CFST columns and steel beams are costlier but keeping in mind, the safety & other factors, the composite members are considered best but as the factor of discussion is Cost here, so only for beam & columns the RCC costs less. The graphical representation of Total cost is shown as below in Figure 6.21.

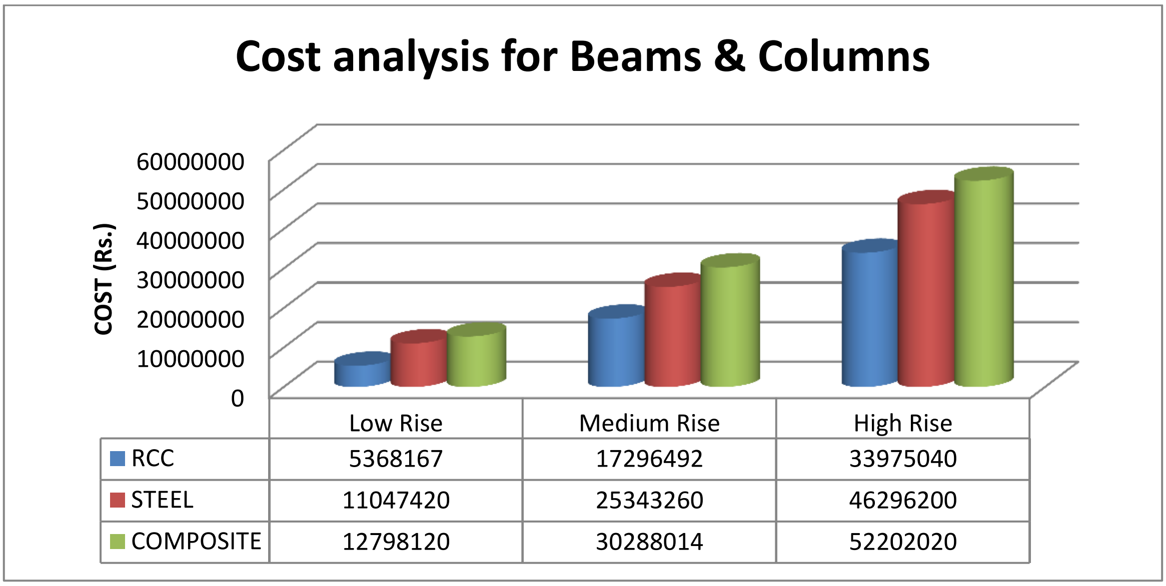


Figure 6.21 Cost Comparison For Beams & Columns in Low, Medium & High Rise Structure

CHAPTER 7
CONCLUSIONS

1) From the base shear results of 11story, 21story and 31story RCC, steel & composite frame building, it is found that the base shear value is low in steel frame as compared to composite frame & RCC frame. The seismic weight of steel structure is less due to which the response of steel structure is better in comparison to other structures during earthquake.
2) In composite structures, the maximum story displacement is minimum than RCC structures & steel structures. For 31 storey structure, permissible limit of displacement is 186mm as per IS codes deflection criteria and RCC structure top story displacement was 175mm very near to permissible limit. Therefore, for high rise building more than 31 story with this type of geometry, RCC building fails.
3) The maximum storey drifts is minimum is composite structures but for all the structures, storey drifts values are within limits. Storey drift results are better for Response spectrum analysis in comparison to equivalent static load method. Storey drift can be reduced by introducing more shear wall or bigger size columns at particular locations of the building.
4) The reason for increment in modal frequency & decrement in time period of composite increased stiffness as compared to other structures.
5) The composite structures are more preferable to RCC & steel structures due to better response during earthquake.
6) So the final conclusion from the dynamic & static analysis is that the RCC structures are best for low rise buildings, steel structures are good for industrial sheds, roofs etc. & composite structure are considered better for high rise &medium rise structures.
7) Cost of Beams & Columns is less in RCC But after consideration of different members like footing, slab , connections etc. these results may differ.
8) Time consumed for construction of steel & composite structures is also very less in comparison to RCC building.

CHAPTER 8

FUTURE SCOPES

1) The complete cost analysis can be done, keeping in view all the factors like slab, footing, shear studs, connections , cost of formwork, labour , machinery cost etc. and complete results can be calculated so that there is better and clear idea about the cost included in construction.
2) Different irregular Plans of buildings can be designed for various heights to get more clearance about building safety factors.
3) Soil investigations can also be considered in detail for research.
4) The buildings can also be analysed by Time History method and pushover analysis to get better results.

REFERENCES

[1] V Ganwani Nileshkumar and Dr. Jamkar S.S.(2016). "Comparative study on RCC and Steel-Concrete Composite Building using Linear Static Analysis." *International Journal for Scientific Research and Development 4.2 : 213-216.*

[2] Kolhe, Prasad, and Shinde Rakesh(2015). "Time History Analysis Of Steel And Composite Frame Structure." *IJREAT International Journal of Research in Engineering & Advanced Technology, Volume 3, Issue 2.*

[3] Warade Nitin m. and Salunke P. J. (2013) ,"Comparative study on Analysis and Design of Composite Structure", *International Journal Of Advance Research In Science And Engineering IJARSE, Vol. No.2, Issue No.12, pp- 41-50.*

[4] Sangave Prakarsh, Madur Nikhil, Waghmare Sagar, Shete Rakesh, Mankondi Vinayak and Gundla Vinayak (2015**)**. "*Comparative Study of Analysis and Design of RC and Steel Structures." International Journal of Scientific & Engineering Research 6.2.*

[5]. Cholekar, Swapnil B., and S. M. Basavalingappa (2015). "Comparative Analysis of Multistoried RCC and Composite Building due to Mass Irregularity." *International Research Journal of Engineering and Technology 2.04 : 603-608.*

[6] Mohite Nitish A.,Joshi PK, and Deulkar WN(2015)."Comparative Analysis of RCC and Steel-Concrete-Composite (B+G+ 11 Storey) Building." *International Journal of Scientific and Research Publications 5.10:1*

[7] Charantimath, S. S., B. C. Swapnil, and M. Birje Manjunath(2014). "Comparative study on structural parameter of RCC and composite building." *IISTE Civil and Environmental Research 6.6 : 98-110.*

[8] Panchal, D. R., and P. M. Marathe(2011). "Comparative study of RCC, steel and composite (G+ 30 Storey) building." *Institute of Technology Nirma University, Ahmedabad-382 481: 08-10.*

[9] Wagh, Shweta A., and U. P. Waghe(2014). "Comparative study of RCC and steel concrete composite structures." *IJERA 4.4 (2014): 369-76.*

[10] Prajapati, Baldev D., and D. R. Panchal(2013). "Study of Seismic and Wind Effect on Multi Storey RCC, Steel and Composite Building." I*nternational Journal of Advances in Engineering & Technology 6.4 : 1836.*

[11] Begum Mahbuba, Salekin Md. Serajus, Khan N.M. Tauhid Belal and Ahmed W. (2013) "Cost Analysis of Steel Concrete Composite Structures In Bangladesh." *Asian Journal of Civil Engineering (Bhrc) 14.6 : 935-944*.

[12] Koppad, Shashikala, and S. V. Itti.(2013) "Comparative study of RCC and composite multi-storeyed buildings*." IJEIT 3.5: 341-5.*

[13] http://www.meps.co.uk/indian%20steel%20prices.htm